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Michael E. Auer
Tiia Rüütmann *Editors*

Educating Engineers for Future Industrial Revolutions

Proceedings of the 23rd International Conference on Interactive Collaborative Learning (ICL2020), Volume 2

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Michael E. Auer · Tiia Rüütmann
Editors

Educating Engineers for Future Industrial Revolutions

Proceedings of the 23rd International Conference on Interactive Collaborative Learning (ICL2020), Volume 2

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Preface

ICL2020 was the 23rd edition of the International Conference on Interactive Collaborative Learning and the 49th edition of the IGIP International Conference on Engineering Pedagogy.

This interdisciplinary conference aims to focus on the exchange of relevant trends and research results as well as the presentation of practical experiences in interactive collaborative learning and engineering pedagogy.

ICL2020 has been organized by University of Technology Tallinn, Estonia, from September 23 to 25, 2020, as an online event.

This year's theme of the conference was "Educating Engineers for Future Industrial Revolutions."

Again outstanding scientists from around the world accepted the invitation for keynote speeches:

- **Ruth Graham**, Higher Education Consultant, USA. Speech title: ***Reward and Recognition of University Teaching***
- **Tarmo Soomere**, President of Estonian Academy of Science. Speech title: ***Connecting Science, Training, Society and Policy***
- **Hanno Hortsch**, Technische Universität Dresden (TUD), President of IGIP. Speech title: ***The New Prototype Curriculum of IGIP in Engineering Pedagogy***

The following very interesting workshops have been held:

- ***Teaching Environmentally and Sustainability-Conscious Design Projects in Higher Education, using GRANTA EduPack***
  Facilitator: **Vakhitova Tatiana Vadimovna** PhD, ANSYS Granta/Academic Relations Team (UK)
- ***Decentralizing Education Using Blockchain Technology***
  Facilitator: Dr. **Alexander Mikroyannidis**, Knowledge Media Institute, the Open University (UK)
- ***Idea Generation Board Game for Product Development "Create Products"***
  Facilitators: **Erich Scheffl** and **Jürgen Jantschgi**, (Austria)

- ***IGIP Workshop on methodologies to build conceptual questions for assessing important misconceptions in engineering related areas***
  Facilitators: **Teresa Restivo** and **Diana Urbano** (Portugal)

We would like to thank the organizers of the following special sessions:

- ***Games in Engineering Education (GinEE)***
  Chairs
  Matthias C. Utesch, Technical University of Munich, Germany
  Marek Milosz, Faculty of Electrical Engineering and Computer Science, Lublin University of Technology, Poland
- ***Entrepreneurship in Engineering Education 2020" (EiEE'20)***
  Chairs
  Stefan Vorbach, University of Technology Graz, Austria, stefan.vorbach@tu-graz.at
  Jürgen Jantschgi, HTL Wolfsberg, Austria, juergen.jantschgi@htl-wolfsberg.at
- ***Public-Private Partnership in Engineering Education (SYNERGY)***
  Chair
  Svetlana V. Barabanova, Kazan National Research Technological University, Russia
- ***IoT, IIoT and Energy Harvesting in Future of Industrial Revolution (IoT-EHFIR)***
  Chairs
  Doru Ursutiu and **Paul Nicolae Borza**, "Transilvania" University Brasov, Romania

Since its beginning, this conference is devoted to new approaches in learning with a focus to collaborative learning and engineering education. We are currently witnessing a significant transformation in the development of education. There are at least three essential and challenging elements of this transformation process that have to be tackled in education:

- the impact of globalization and digitalization on all areas of human life, and
- the exponential acceleration of the developments in technology as well as of the global markets and the necessity of flexibility and agility in education
- the new generation of students, who are always online and do not know live without Internet

Therefore, the following main themes have been discussed in detail:

- Collaborative Learning
- New Learning Models and Applications
- Project-Based Learning
- Game-Based Education
- Educational Virtual Environments
- Computer-Aided Language Learning (CALL)
- Teaching Best Practices

- Engineering Pedagogy Education
- Public-Private Partnership and Entrepreneurship Education
- Research in Engineering Pedagogy
- Evaluation and Outcomes Assessment
- Internet of Things and Online Laboratories
- IT and Knowledge management in Education
- Real-World Experiences

As submission types have been accepted:

- Full Paper, Short Paper
- Work in Progress, Poster
- Special Sessions
- Round Table Discussions, Workshops, Tutorials

All contributions were subject to a double-blind review. The review process was very competitive. We had to review more than 400 submissions. A team of about 225 reviewers did this terrific job. Our special thanks go to all of them.

Due to the time and conference schedule restrictions, we could finally accept only the best 156 submissions for presentation.

The conference had near 200 online participants from 34 countries from all continents.

Our special thank goes to **Anton Jegorov** and the technicians of University of Technology Tallinn, who made the online conference a reality. We thank **Sebastian Schreiter** for the technical editing of this proceedings.

ICL2021 will be held in Dresden, Germany.

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Engineering Pedagogy Education

Work-in-Progress: Development of the Discipline "Innovations in Engineering Pedagogy" as Part of an Advanced Professional Training for Educators of Engineering Schools in Higher Education Institutions

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Abstract. Engineering workforce fuels high-pace technology developments in all aspects of human life. A quality of engineering education today is essential to build engineers for tomorrow. This raises standards for pedagogical training for professors and other staff of engineering educational institutions.

The framework of ERASMUS + project "EngineeriNg educaTors pEdagogical tRaining" ("ENTER") provides a venue for partnership between universities to develop and enhance curriculum. This article provides results of collaboration of KNRTU with thirteen universities from Europe, Kazakhstan and Russia in an effort to develop a Multi-Level Modular Curricula "Innovative Pedagogy for Engineering HEIs' Educators" (iPET) for the advanced professional training of the "educator of the future". In this work, creativity is identified as a key component of professional competence of an educator. As such, main goal of the discipline is to boost creativity of educator, to practice conventional and contemporary innovative pedagogical techniques and to build confidence to implement them in professional activity. Understanding of motivation, operational conditions, creative thinking, ability to reflect and their interconnections is necessary for successful implementation of the course. Analysis of innovative pedagogical technologies was also conducted as part of this work. It was established that the most promising are mind-maps, concept maps of literature review, Thesaurus description of terminological systems, so called Thesaurus maps. Research concluded, that the best results are expected when training is continuous, but administered in sessions, alternated with periods of practicing in a workplace. This allows educators and students to adapt to new techniques and master fewer of them at a time.

This article summarizes methods, tools and organizational forms that are recommended for use in the discipline "Innovations in Engineering Pedagogy".

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Keywords: Engineering Pedagogy · ERASMUS+ «ENTER» project · Innovative pedagogical activity · Case study · Mind-maps · Tools for creative tasks solving

1 Introduction

According to "Forecast of scientific and technical development of the Russian Federation for the period until 2030" [1] information and communication technologies, biosciences, rational use of natural resources, new materials and nanotechnologies, transport and space systems as well as energy efficiency and energy saving are the priority areas for Scientists and Technologists. Analysis of this document shows that engineering education is essential for addressing modern socio-economic, scientific, technological challenges. Thus, higher education should meet raising standards of engineering workforce.

It should be noted that new technologies which are being developed require forward looking approach to engineering education. This means that future specialist need to have necessary skills and be able to use methods and means of working with them. That said, a process of engineering education should put emphases on developing creativity and teach to adapt to rapidly changing technology landscape. New pedagogical methods should be developed based on modern scientific and manufacturing technologies and leverage rapidly-growing informational and telecommunication facilities. Following the pace of technology evolution present a challenge to the educator. Historically, less experienced educators have been mentored by their highly skilled peers, which is a good basic knowledge sharing practice. However, it is unlikely to lead to development of innovative educational methods and approaches, that meet demand of industry 4.0 and labor market. Thus, it is important that skills of educational staff of engineering schools promote innovative and out-of-the-box thinking among students. That's why inclusion of "Innovations in Engineering Pedagogy" course in advanced training for engineering educators is an important step towards increasing educational standards and meeting demands of modern World.

2 Creativity - Key Component of Professional Competence of an Educator

The framework of ERASMUS + project "EngineeriNg educaTors pEdagogical tRaining" ("ENTER") provides a venue for partnership between universities to develop and enhance common educational standards. Today, KNRTU in cooperation with thirteen universities from Europe, Kazakhstan and Russia, develop a Multi-Level Modular Curricula "Innovative Pedagogy for Engineering HEIs' Educators" (iPET) for the advanced professional training of the "educator of the future".

Many universities around the World are engaged in similar activities. For example, International Society for Engineering Pedagogy (IGIP) developed a course for engineering educators that laid a ground for the development of iPET program. Another example is the work in the field of engineering pedagogy is the curriculum approach of

Scientific Society for Engineering Education (IPW), developed by the international work group of specialists.

"ENTER" project studies modern engineering labor market and considers needs of stakeholders. One of the iPET program disciplines, "Innovations in Engineering Pedagogy" promotes creativity and use of innovative educational technologies. Innovative professional pedagogical activity implies creative approach to non-standard professional problems and high level of professional competency [4, p. 93]. Readiness to apply innovative approach is defined by educator's motivation, operational conditions, creative thinking and ability to reflect.

Motivation to implement innovative professional pedagogical activity means the desire to create, master and use innovations in pedagogical activity: business simulation games, methods of problem-based and heuristic education.

Operational conditions characterize innovative activity from the stand point of skills and abilities of its implementation, mastering of innovative methods, tools and technologies. The development of this component relates to mastering pedagogical innovations.

The development of creative thinking implies problem solving skills, flexible and open thought process and brainstorming. Development of this component requires mastering of heuristics methods in the context of professional situations in advanced training.

Finally, innovative professional pedagogical activity includes the ability to reflect and analyze. The core component of innovative professional pedagogical activity is motivational which manifests in the educator's desire to create, master and use innovations: case studies, methods of problem-based, heuristic and developmental teaching [4].

The main goal of the discipline "Innovations in Engineering Pedagogy" is to mature creativity of educator, practice of conventional and contemporary innovative pedagogical techniques and readiness to implement them in professional activity.

"Problem-based, Project-based and Practice Oriented Learning", "Enhancement of Learning Interactivity" and "Engineering Innovation Process" are other disciplines of iPET course that have interdisciplinary overlaps.

3 Analysis of Innovative Pedagogical Technologies for Development of the Discipline "Innovations in Engineering Pedagogy"

There is variety of innovative educational technologies. In this work, we would like to highlight those, that according to our analysis, are most promising, universal and appropriate for use in the abovementioned discipline. This includes organizational forms, methods and tools that can be easily acquired and serve to motivate educators to use them in practice. For example, mind maps - is a multifunctional educational tool that allows to develop students' creative abilities. There are multiple web sites where educator can create online mind maps, using Moodle and Blackboard platforms. Creating online mind maps one can use hyperlinks, an editor, and give any keyword the status of a center. Online mind-maps are effective tools from the point of view of student's motivation, because they are easy to create and this allows students to obtain quick result from their own mental activity, without any criticism, confusion, long and tiresome speculations [5].

The distinctive feature of the educator's activity is that every year there is an increase in the number of the necessary professional information. Advanced vocational training provides the possibility to obtain professionally relevant information that is preliminary selected, systematized and generalized. However, since educator attends the advanced vocational training courses every 3 years the volume and variety of the information that the educator should acquire is considerable. This fact creates great problems with its memorizing and the use in practice.

Mind maps help to solve the problem of large volume of important information acquisition, its transformation into educator's "intellectual property" and is essential for the intensification of education and thus for the level of professional competency. Supportive notes in the form of mind maps help stimulate cognitive activity of the learners, facilitate the retention of big volume of information. The value of this method is in visualization of verbal information, which makes it easier for most people to memorize. For instance, information from color-coded plots will retain longer in memory.

Pedagogical research is an important part of HEI educator's job. Another effective way to organize the information for disciplinary writing in the form of contributions to grant proposals, peer-reviewed journal publications, and conference papers is the use of "Concept Map of a Literature Review" [6]. We suggest to include this tool into the discipline's content because it helps to locate relevant primary literature quickly, create literature concept maps to organize disciplinary knowledge and identify areas for investigation. Conceptual mapping also provides a sense of order and command over, what might at first, seem like a vast and overwhelming domain of disconnected articles. This would be helpful for post-graduate students in their research.

Sarah Lyn Gassman et al. suggest that creation of a "Concept Map of a Literature Review" should begin with large blank sheets of paper, which can be easily found at any office supply store (large flip chart pads or butcher paper rolls). Students should also use pencils so they can easily make changes to their map. Together with students the teacher should identify the concepts or ideas that are fundamentally guiding the student's search for relevant literature. Then, the students are asked to determine the relationships between these concepts.

For example, hierarchical relationships may exist in which some concepts serve as a broad category for a series of more limited concepts. As students' understanding of the concepts and their interrelationships begins to solidify, they can add citations to their map to indicate articles that support, complicate, or even contradict the emerging understandings of how concepts 'fit together' to form the larger picture. Teacher should encourage students to remain cognitively flexible as they construct and reconstruct their map. As their understanding of the area advances, they will likely make substantial changes in their map.

Another tool that can be introduced to ease the representation of the semantic structure of psychological and pedagogical sciences for educators attending advanced training courses is thesaurus description of terminological systems. L.I. Gourier and L.

L. Markina consider that from didactical point of view the most interesting are those relationships that are translated into the language of standard thesauruses as "higher - lower" relationships. On the basis of this approach, educators can be asked to compose thesaurus maps from a list of the used terms. So, it is necessary to distinguish the types of semantic relations that connect groups of terms.

Within the framework of the discipline "Innovations in Engineering Pedagogy", the study of the principles of case study design will allow educator to develop his own case and adapt it to required knowledge level and academic program. Based on recommendations of American scientists, key principles of their development can be distinguished as following:

1. The presence of the storyline and characters in the case. TV programs, films and documentaries can be a source of ideas for a case problem statement. It is important that case is relevant and present an interest to the audience. Scientific journals written in accessible language intended for a wide audience can be used as well.
2. Development of a case based on the "Case Difficulty Cube" (J. Erskine and M. Leenders) [7] allows to determine optimal amount and complexity of information in the case, necessary for the development of students' cognitive interest, their self-confidence which has three parameters - analytical, conceptual and presentational [8, 9]. Respectively, cases can be complex, according to each parameter.
3. The use of different ways of case presentation to students, for example, the incomplete case method, in which the teacher provides students with incomplete data on the problem, as well as a hypothesis, the students in turn, conduct a research, then voice their own version of the problem solution.
4. The use of an "open-ended" question, which implies multi-variant answers, for the effective start of a discussion on the subject of the case.
5. The use of "6 thinking hats" and tools to solve the problem of the case [10, 11].

The goal of our discipline is to give educator simple and universal methods to motivate students to use them during their study and continue to apply them in their career. We recommend twelve tools for creative problem solving, which can be arranged in three groups:

1. Tools for attention concentration, expansion of perception, which allow to define the problem and its root-cause analysis.
2. Tools for search of gaps. They highlight missing information, and assumptions gaps while considering a problem. Also, they can be used to identify consequences of an activity.
3. Lateral thinking tools for generation of new ideas.

The advantage of case study method is that it is a universal method and can be used while studying any discipline.

Active, innovative learning methods can also be intensified by educator by organizing his students in small groups with the use of moderation techniques. Small groups can be structured based on students' preferences. Sociometry can be used to create heterogeneous groups with friendly team environment. It is advisable that roles within a group are rotated. This is an important aspect because modern innovative activities are multidisciplinary. Students are exposed to different roles, such as group leader, facilitator, minutes taker and so on. This gives students awareness of different behaviors and helps build their own style. Such skills help young professionals to navigate cross-functional teams.

Among other tools that belong to active learning methods providing active student engagement and developing creativity are problem-based learning, telecommunications projects and flipped classroom.

As for the procedural innovations at advanced training courses, special attention should be given to step-by-step training which means that the periods of training alternate with the periods of work at the institution. In this case, between the stages of their training, the attendants have the opportunity to compare recently acquired knowledge with traditional ones, to comprehend them, check theoretical material in practice and find the most optimal ways and methods of work [15].

Self-analysis/reflection is a component of the educator's innovative activity that provides quick feedback on the results of pedagogical actions. Decision making and pedagogical improvisation are considered as the highest stages of self-analysis/reflection [16] and they are also viewed as the highest degree of professionalism of an educator.

Creativity is considered as critical factor to the success of reflection development [17–19]. Educator's reflection can be developed through designing creative situations in the educational process of advanced training.

At the first stage, course attendants are immersed into the theory of reflection. For example, they are given small fragments from articles or texts about reflection, then on the basis of these texts, they are offered to discuss such questions in a group as "When does reflection appear in a person's mind?", "What does the development of reflection give to a person?" or "Do you agree with the following statements?". After reading the article "Pedagogical reflection in the educational activities of adults" they must answer whether they agree with the general conclusion made by the authors at the end of the article.

At the next stages course attendants design a "case" on the topic "Pedagogical Reflection" in their self-analysis diary and offer it for a solution to their small group members. The case that appeared to be the most interesting one is presented for a large group discussion. The cases under study contain a situation from pedagogical practice, and each member of the group offers his own decision, indicating the type of pedagogical position, according to G.A. Abramova [20]. Reflective essays, the project-based technique "Cactus" and others are also effective and can be offered in the course.

We believe that analysis of innovative pedagogical technologies presented above, provides comprehensive framework for the development the Discipline "Innovations in Engineering Pedagogy.

4 Conclusions

Analysis of "Forecast of scientific and technical development of the Russian Federation for the period until 2030" [1] reveals that engineering education is essential for addressing modern socio-economic, scientific and technological challenges. This demands current Higher education standards to meet raising requirements of engineering labor market of the future.

Pedagogical skills of Educators of Engineering Schools in Higher Education Institutions play important role in development of competitive engineering workforce for tomorrow. To meet this challenge, KNRTU joint efforts with universities from Europe, Kazakhstan and Russia to develop a Multi-Levell Modular Curricula “Innovative Pedagogy for Engineering HEIs’ Educators” (iPET) for the advanced professional training of the “educator of the future”. Such collaboration was made possible under the umbrella of ERASMUS + project “EngineeriNg educaTors pEdagogical tRaining” (“ENTER”). In this work, creativity is identified as a key component of professional competence of an educator. Subject discipline develops educator’s creativity through four major components: motivation, operational environment, creative thinking and ability to reflect. It is also important to acknowledge and understand interconnections that exist between components.

Our research has identified “Mind-maps”, “Concept Maps of a Literature Review”, “Thesaurus description of terminological systems” (Thesaurus maps) as most promising and universal organizational forms, methods and tools. We recommend those methods to be included in the abovementioned curricula.

We concluded that a “case study” is one of the most efficient forms of engineering education. It exposes students to real-life problems, stimulates their creativity and provides a concise overview of lessons learned. However, effectiveness depends on educator’s skills to properly build the case and present it in the right context. In our course we share best practices of creating a case study and provide simple and universal tools for creative problem solving. An advantage of such approach is that these are universal methods that can be used by students during study of any discipline and continue to remain relevant in their career.

A special attention in our work was given to help educator identify the most effective ways of administering engineering courses. Our analysis suggests that smaller groups of students, generally, yield better results. However, we do not suggest that groups are set up randomly. We provide guidance to the educator to consider students preferences and use sociometry to create heterogeneous groups with friendly team spirit. Such format gives students a chance to exercise different roles within a team, become aware of various behaviors, and develop their personal style.

A success of any pedagogical activity is hinging on ability to reflex and adjust. This is especially important in the area of advanced education because progress is achieved in smaller steps, which may be less sensible as compared to prior educational levels. Our course helps educators recognize different stages of self-estimation and develop appropriate behaviors. This play a crucial role in self-estimation of your own performance, as well as actions conducted by audience. This is achieved via number of exercises and is repeated through the duration of the course.

We expect that best results when training continues throughout pedagogical career. Given high volume of information and individual learning pace, we recommend that advanced training is held in sessions, alternated with periods of practicing acquired skills in a workplace. This allows educators and students to adapt to new techniques and master fewer of them at a time.

Research work done by our team provides data-based recommendations for a Multi-Level Modular Curricula “Innovative Pedagogy for Engineering HEIs’ Educators”. Although this activity is work-in-progress, results achieved to date are an important milestone on the way of shaping pedagogical standards for engineers of tomorrow.

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Design and Implementation of the International Center of Engineering Education at the University of Talca (Chile) Under IGIP and the Dresden School of Engineering Pedagogy Tradition

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Abstract. This paper introduces the International Center of Engineering Education (CIEI) at the University of Talca (Chile), founded under principles, research and scientific work of IGIP and the Dresden School of Engineering Pedagogy. The starting point of CIEI was the cooperation between engineering faculties of Chilean universities and the TU Dresden in the PEDING-Project (research project in Engineering Education), led by Prof. Hanno Hortsch (TU Dresden-IGIP). Its main goal was designing a training course, based on IGIP curriculum, to improve the teaching quality of engineering educators, identifying some needed pedagogical competencies for teacher training, and skills and technological tools for engineering teaching related to industrial requirements. This course was the basis for a preliminary twelve modules training program developed by CIEI according to the learning module structure of IGIP and the TU Dresden. CIEI seeks to expand and continue the IGIP and the Dresden traditions of Engineering Education in Chile and Latin America, through the implementation of a training program for engineering educators, and the establishment of an international network for research and innovation in engineering and technology education between universities and companies in Latin-American and European countries.

Keywords: Engineering educators training · Engineering pedagogy and education · International Center of Engineering Education

1 Introduction

From the 1950s were founded and developed three "schools" or traditions of Engineering Pedagogy in Europe: the Dresden, the Prague and the Klagenfurt school of Engineering Pedagogy [1]. The experiences of these three European schools of engineering pedagogy became the theoretical basis for the founding of IGIP (International Society of Engineering Pedagogy) in 1972 in Klagenfurt, Austria. It is important to mention that the

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Schools for Engineering Education in Austria and Czechoslovakia were founded based on the theoretical and practical achievements of the Dresden´s workgroup. The main initiatives in the field of engineering pedagogy of the Dresden School, in cooperation with representatives of the Prague and the Klagenfurt schools, have significantly influenced the formation of the specific characteristics of the international movement in this area, which has been concretized through the worldwide activities of IGIP and IFEES (International Federation of Engineering Education Societies) and other organizations. The beginning of the Tradition of the Dresden school of Engineering Pedagogy dates from 1951 with the foundation of the Institute of Engineering Pedagogy at the Technische Universität Dresden (TU Dresden, Germany), but before that, were other academic activities that make it easier to initiate the Engineering Pedagogy activities at TU Dresden. The TU Dresden works since 2014 in cooperation with Chilean universities to strengthen Engineering Education. This goal was concretized, through the first cooperation project "Engineering Didactics at Chilean Universities" (PEDING-Project, financially supported by DAAD) under the guidelines of the Engineering Pedagogy Tradition of the Dresden school of Engineering Pedagogy at the TU Dresden. This cooperation has laid the basis for the establishment and foundation of the International Center of Engineering Education in Chile at the Universidad de Talca, one of the participating Chilean universities of the PEDING-Project.

2 Engineering Pedagogy: From Dresden to Chile

2.1 The Development of the Dresden School of Engineering Pedagogy

From 1924 until today, the development of the Dresden School of Engineering Pedagogy can be summarized in four main phases depending on the different time periods and the contributions of the different professors in charge in those periods, who led the pedagogical and research activities at the School [2, 3]:

From 1924 to 1963. In 1924 Prof. Seyfert established at the TU Dresden (Institute of Pedagogy) a two-semester supplementary course for the development of teaching qualifications of graduate engineers and graduate economists who worked at commercial academies and technical and vocational schools. In autumn 1946, after the Second World War, the teaching at the TU Dresden began again at three faculties, including the Faculty of Education (from 1949 known as the Faculty of Education and Cultural Studies; and from 1954 as the Faculty of for Vocational Education and Cultural Studies). In 1949 Prof. Hans Lohmann was appointed to improve and to specialize the methodology of mechanical and electrical engineering. Lohmann (Vice-Dean 1950–1956), in his quest to systematize and to professionalize the teaching and research in engineering on an institutional level, founded in 1951 the Engineering Pedagogy Institute (Institut für Ingenieurpädagogik) at the TU Dresden. The starting point of Lohmann's scientific reflections was the connection between the structure of a science and its teaching: every scientific teaching requires first the analysis of the corresponding science to define the teaching contents and the appropiate teching structures for this scientific field or discipline. Engineering science, which seeks and obtains knowledge based on the state of the art (see Lohmann, 1954), requires, therefore, an analysis of technology. From the investigation of theory and practice of technology, Lohmann derives conclusions for the design of the teaching of technology and technics. This was done both for the “internal”, methodical design (goals, structure of contents, methods, and procedures for instance), and for the “external”, organizational design of this teaching (for example, the practice module coordinated based on requirements of the economy and his production and services structures).

From 1963 to 1986. In 1963 Prof. Franz Lichtenecker took over the management of the Institute for Engineering Pedagogy with new scientific reflections. In cooperation with Hering (Dean of the Faculty of Vocational Education and Cultural Studies between 1963–1966) published in 1963 “Solution Variants on the Contents-Time-Problem and Its Order” (Lösungsvarianten zum Lehrstoff-Zeit-Problem und ihre Ordnung). This publication presented new perspectives about didactic questions on Engineering Education and Pedagogy. The solution variants to the contents-time-problem offer~~s~~ possibilities to resolve the permanent dilemma of the increasing amount of knowledge and limited training time. Through very concrete scientific and technical examples they tried to find solutions for this problem. These solutions are derived on a high level of abstraction and thus universal applicability. The solution variants had two main focuses: (i) the “contents restriction” (for example by modeling or didactic simplifications) and (ii) the “qualification for/to a” contents manage (for example developing skills or using algorithms). Through Lichteneker's administration other colleagues at the TU Dresden were able to continue researching and complementing key didactic elements of Engineering Education, for example, the basics of didactic categories for engineering education (e.g. goal, content, method), the supporting organization forms of teaching-learning (e.g. lecture and exercise), laboratory internship in engineering, as well as subject-specific study processes.

From 1986 to 1989. In 1986 Prof. Lehmann started the direction of the Dresden School of Engineering Pedagogy with focus on the research on the entire process of training and further education of engineers, and thus on the design of curricula for entire engineers degree programs at discipline and specializations levels. The curricular phase of the Dresden School by Lehmann was successful in developing modern and holistic design approaches for the training and further education of engineers and at the same time was marked by the economic and political decline of the GDR. Lehmann received the international award IGIP Prize in 1990 for his contributions to engineering education.

From 1992 to the Present. Since 1992 Prof. Eberhard Wenzel led the School of Engineering Pedagogy at the Institute for Vocational Education. His scientific endeavors were aimed at researching the term “university-didactic thinking”. Wenzel defines “university didactics” as a special kind of didactic: his reflections about this term contributed in such a way to understand that the basic concepts of the didactics of vocational education and training should be transferred to the teaching and learning situations in the higher education sector. Other important objectives for Prof. Wenzel were to continue and to expand the traditions of the engineering-pedagogical teaching in the national and international context. A further step in engineering-pedagogical research was presented at the 1st Engineering Pedagogy Colloquium organized at the TU Dresden (February 2000) by Prof. Binger (Faculty of Mechanical Engineering) and

Prof. Hortsch (Faculty of Education). During the period of the professorship for Engineering Pedagogy by Prof. Wenzel was offered a two-semester course focused on "University didactics".

This course aimed to establish a "didactic minimum qualification" on the academic staff and were positively evaluated by the academics at the TU Dresden. Since the retirement of Prof. Wenzel, the work (tradition and innovation) of the Dresden School of Engineering Pedagogy have been continued by the Chair of Didactics of Vocational Learning, under the leadership of Prof. Hanno Hortsch. The chair of Prof. Hortsch leads and develops many research projects focused on Engineering Pedagogy in Germany and different countries. Actually, the majority of the courses with matters in Engineering Pedagogy and Didactics are under responsibility of Dr. Steffen Kersten, Chair of Didactics of Vocational Education at the TU Dresden (Fig. 1).

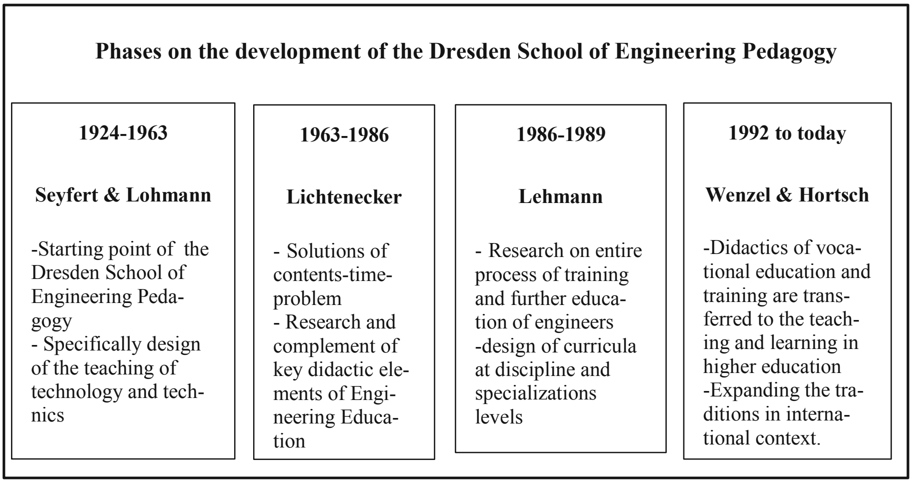

Fig. 1. Phases on the development of the Dresden School of Engineering Pedagogy

2.2 Projects of the Dresden School of Engineering Pedagogy

Engineering Didactics at Saxonian Universities: E-Didact. In 2010 a team headed by Prof. Hortsch and Dr. Kersten (Chair of Didactics of Vocational Learning, TU Dresden), developed the needs-oriented training program "E-Didactic" for academic staff of engineering faculties of Saxony, Germany. The project aimed to develop, implement and test a postgraduate e-learning course offering to develop competencies for the design of teaching and learning processes in the academic engineering higher education. Regarding the university-needs, the project was oriented to: (i) the development of a continuing e-learning course with a strong focus on the design of engineering academic teaching, (ii) the design of goals and contents of the study modules based on the specifics of engineering teaching at universities of applied sciences with specials "close" connection between application and research, and (iii) the areas of mechanical engineering and mechatronics. The program was composed of four main module areas with a total of 12 study modules, with a scope of 20 Credits Points. The core modules are: (I) Engineering didactics fundamentals, (II) Forms of structuring the teaching-learning processes in university contexts, (III) Determining objectives and contents of engineering studies, and (IV) Practical module. In the first stage of the project, a research of pedagogical and didactic needs in the engineering faculties was developed. For this purpose, were implemented class observations, individual surveys and a focus group with the academic staff of the engineering faculties. Module and contents of the study program were determined together with the engineering science staff of the University of Applied Sciences Zittau / Görlitz in a needs analysis and led to the following module structure (see Table 1) The study program was accredited by the International Monitoring Committee of the International Society for Engineering Pedagogy (IGIP) as a study course for the certification "International Engineering Educator ING.PAED.IGIP", and certified by the board of the Engineering Pedagogy Science Society (IPW) as a degree program for the ENGINEER EDUCATOR (IPW) [4].

Table 1. Modules overview of the E-Didactic trainings program "International Engineering Educator ING.PAED.IGIP" TU DRESDEN

Units	Contents * (*simplified version for this publication)
I. Engineering didactics fundamentals	
I.1. Design of teaching- learning processes in engineering sciences	I.1.1. Psychological foundations of teaching and learning I.1.2. Theoretical and practical bases of eng. Didactics I.1.3. Didactic principles I.1.4. Organization of the teaching – learning processes I.1.5. Structuring of the teaching – learning processes
I.2. Didactic media for teaching in engineering	I.2.1. Concepts and classification of didactics media I.2.2. Functions of didactic media and technological tools I.2.3. Field of action of didactic media I.2.4. Elaboration of didactic media
I.3. Communication	I.3.1. Design of communication processes I.3.2. Monologic and dialogic communication procedures I.3.3. Conflict identification and resolution
I.4. Control and Evaluation of the learning outcomes in Engineering Education	I.4.1. Registration and evaluation of the learning outcomes I.4.2. Operationalization of learning outcomes I.4.3. Procedures for the registration of learning outcomes I.4.4. Evaluation of the learning outcomes

(*continued*)

Table 1. (*continued*)

Units	Contents * (*simplified version for this publication)
II. Forms of structuring the teaching-learning processes in university contexts	
II.5. Lectures (theoretical courses)	II.5.1. General structure of a University course planning II.5.2. Preparation of a university course II.5.3. Execution of a university course II.5.4. Feedback in a university course
II.6. Laboratory practical training/self-study	II.6.1. Laboratory training II.6.2. Experiment functions in the teach–learning processes II.6.3. Exercises and self – study planning
II.7. Engineering internships, written reports, research colloquium	II.7.1 Engineering internship and research preparation II.7.2 Support systems for internships and autonomous research II.7.3. Internship analysis and research activities analysis
III. Determining objectives and contents of engineering studies	
III.8. Determination of the study program objectives	III.8.1. Analysis of the activities in engineering III.8.2. Analysis of the activities an engineering study program III.8.3. Analysis of social aspects in engineering III.8.4. Analysis of personal aspects in engineering
III.9. Determination of the engineering study program contents	III.9.1. Fundamentals for the determination of contents III.9.2. Contents determination of an university study programs with regard to the academic activities III.9.3. Contents determination of an university study programs with regard to the societal activities III.9.4. Contents determination of an university study programs with regard to the personal activities
IV. Practical module	
IV.10. Case discussion	IV.10.1. Exemplary documentation IV.10.2. Exemplary reflection IV.10.3. Exemplary evaluation
IV.11. Classes observation	IV.11.1. Documentation IV.11.2. Reflection IV.11.3. Evaluation
IV.12 Final Colloquium	IV.12.1. Planning IV.12.2. Implementation IV.12.3. Evaluation

During and after the implementation of the modules of the training program, an evaluation survey was applied. The evaluation results of the project “Engineering Didactics at Saxonian Universities: E-Didact” show a positive response of the participants of the courses. The success of the project was not only evident in the results of the formative and summative project evaluation, but also revealed in the module implementation at the last project phase, in which the academic staff showed high commitment in his independently work [4].

Engineering Pedagogy at Chilean Universities. Between 2014 and 2018 the Chair of Prof. Hortsch (Didactic of Vocational Education, Faculty of Education TU Dresden) headed the research project “Engineering Pedagogy at Chilean Universities” (PEDING project). The project was financially supported by DAAD and had the participation of academics from engineering faculties of three universities from different regions of Chile: Universidad Autónoma de Chile (Santiago, Talca y Temuco), Universidad de Magallanes (Punta Arenas) and Universidad de Talca (Curicó y Talca). The research project offered, for the first time at the Chilean context, a scientific discussion about the concept of Engineering Pedagogy and established clear guidelines and concrete activities for its installation and development at the university context [5]. The project tried to improve the quality of the engineering education through the participation of the engineering teaching staff in a needs-based continuing education training program. At the first project stage, an analysis about needs on Engineering Pedagogy of the faculties staff was conducted. For this reason, the course presented a strong orientation to Engineering Education and was specifically aimed at teaching staff of the Chilean faculties of engineering, with modules built and structured specifically for engineers and included relevant examples for this group [6]. The training course consisted in six modules, each of 1,5 SCT-Chile (ECTS), and was developed based on the curriculum of the training program “International Engineering Educator ING.PAED.IGIP” from the E-Didactic project of the TU Dresden. Table 2 presented a module overview of the PEDING project [7].

Because the academic staff from different universities and regions of Chile (Concepción, Punta Arenas, Santiago, Talca y Temuco) came, the course was designed in blended learning modality with a total duration of six months (one module per month). The course started in April 2018 with a participation of 35 academics. Given the characteristics of the participants and their institutions of origin, the face-to-face sessions were carried out via video streaming (REUNA-ZOOM), to facilitate the participation of the academics. Autonomous and collaborative work was promoted through the use of technological tools in the course platform (Moodle). In general, the evaluation results from the participants showed that: (i) the subject addressed and the attitude

Table 2. Modules overview of the PEDING trainings course

Module	Units * (* simplified version for this publication)
1. Teaching and Learning Process Design in Engineering Education (EE) (1.5 CP)	Unit 1 - Engineering Teaching Perspectives Unit 2 - Some main aspects of Engineering Teaching Unit 3 - Organization of the Teaching and Learning Processes in the education of Engineering Sciences
2. Communication – Design of communicative processes in Teaching and Learning (1.5 CP)	Unit 1 - Introduction to the design of communicative processes Unit 2 - Important "monological" and "dialogical" communicative procedures in teaching Unit 3 - Recognition of conflicts and solution Unit 4 - Fundaments of intercultural communication
3. Didactic Media in EE (1.5 CP)	Unit 1 - Concepts and applications of didactic Media Unit 2 - Fields of actions of didactic Media Unit 3 - Function of the didactic Media and technological tools Unit 4 - Legislative bases for communication Media Unit 5 -Bases for the elaboration of didactic Media
4. Control and Evaluation of the Learning Results in EE (1.5 CP)	Unit 1 - Function of records and evaluations of the learning results in universities Unit 2 - Personality Models Unit 3 - Reference standards to the performance evaluation Unit 4 - Procedure of the learning results record Unit 5 - Evaluation of the learning results
5. Laboratory Didactics in EE (1.5 CP)	Unit 1 - Basics of design of laboratory training Unit 2 - Experiments in knowledge discovery Unit 3- Functions of experiments in the teaching-learning process Unit 4 - Planning for exercises and self-study
6. Project Based Learning (PBL) in EE. (1.5 CP)	Unit 1 - Getting ready for Project-Based Learning Unit 2 - PBL as a methodology that considers engineering situations for the self-regulation of the learning of a group of students Unit 3 - Problem-Based Learning in Professional Ethics and Social Responsibility in Engineering

of the lecturers of the topics were highlighted, (ii) 98% of the participants affirmed that they were able to identify and improve their personal characteristics to be better prepared for their lectures, (iii) 86% of the participants in the program would be interested in increasing and improving their knowledge about the teaching/learning process in the training of engineers. The successfully results of the PEDING project laid the starting point of new research projects and many recently university activities at the field of Engineering Pedagogy at Chilean context [7].

3 Engineering Pedagogy at the University of Talca

3.1 Foundation of the International Center of Engineering Education

Based on the work at the PEDING research project, the Faculty of Engineering at the University of Talca grounded in 2019 the International Center of Engineering Education (CIEI). Its mission is to establish an academic space within the University of Talca aimed at developing collaborative research in the field of Engineering Education, promoting academic-teaching development in Engineering, as well as regional scientific, economic and social development and national, under the standards of the International Society for Engineering Pedagogy (IGIP). The specifics goals of CIEI are: (1) to offer training courses for academic staff from engineering faculties, who seek to strengthen their teaching skills and to promote innovation in teaching methodologies, (based on the IGIP curriculum approach), (2) to innovate in areas of the curriculum development and teaching and learning methodologies in the context of 21st century Engineering, (3) to develop teaching and learning tools for the development of the competencies of the students of the Engineering Faculty, and (4) to investigate in areas related to university teaching in Engineering and the needs and demands of the cultural, economic and social context that influence the professional work of engineers. Considering the above, it can be understood that the work of CIEI is oriented to:

1. Scientific productivity (publications, projects, seminars, among others) in Engineering Education.
2. Curricular improvement and updating of engineering careers under international standards.
3. Development of new methodologies and technological tools for Engineering Education.
4. Development of a national and international network on Engineering Education and Pedagogy issues with the participation of Chilean universities, companies, and other social actors.
5. Implementation of an international training program for academics from engineering schools, certified by IGIP.
6. Organization of national and international conferences and seminars at the University of Talca.

3.2 The Development of a Needs-Based Training Program on Engineering Pedagogy

The Needs Analysis in Engineering Pedagogy. Supported by the academic staff of the Chair of Didactic of Vocational Education of the TU Dresden and their experience in the PEDING project, the academic staff of CIEI started their work in March 2019. The first scientific stages for the curriculum development of a training course on Engineering Pedagogy were oriented for needs-analysis results of the three surveys of the PEDING Project, in which the academic staff from different Chilean engineering faculties participated.

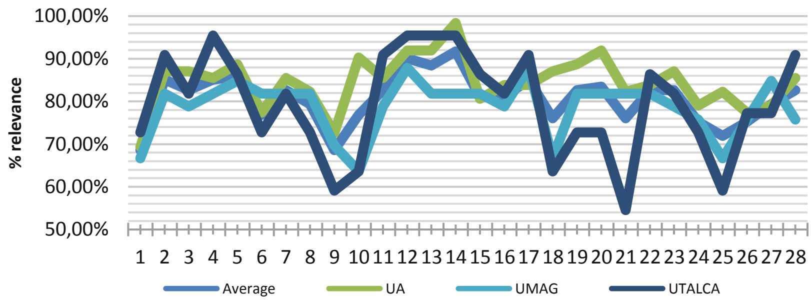

Fig. 2. Relevance of the different aspects consulted about "Perception and needs in Engineering Pedagogy" by university

The analysis of the results of the surveys showed the perception and needs in Engineering Pedagogy and Education at the investigated universities. In general, from the surveys results about different needs in the field of engineering pedagogy and didactic were identified: (i) "Evaluation and assessment of the students' learning achievements", (ii) "Theoretical and practical knowledge about the didactics for the teaching and learning process in engineering", (iii) "Organization of teaching and learning processes for the scientific formation of engineers", (iv) "Use of didactic resources and of information and communication technologies" (ICTs) and (v) "Knowledge about how to design effective measurements of the learning accomplishments" among others. The main results are related to the different answers to the main question "How necessary do you consider the following aspects of Engineering Pedagogy in relation to your teaching experience?" For this section and to answer this question, 28 different aspects were considered based on the criteria applied and the results of the E-Didactic project. Figure 2 shows the results by indicator/aspect differentiated by university. The most relevant aspects are related to the evaluation methods, among which stand out with more than 95% of the preferences aspects such as: "*Evaluation and assessment of achieved learning*" and "*Knowledge about design for effective measurement of* *achieved learning*". Then with more than 87% of the preferences are aspects such as: "*Structuring of teaching-learning processes in the scientific training of engineers*", "*Use of didactic resources and information and communication technologies*" (ICTs). The aspects with the lowest relevance were: "*Curriculum development for academic training at the university level*", "*Realization of communicative processes for teaching at university level*" and "*Planning and materialization of evaluation and evaluative processes*" [7].

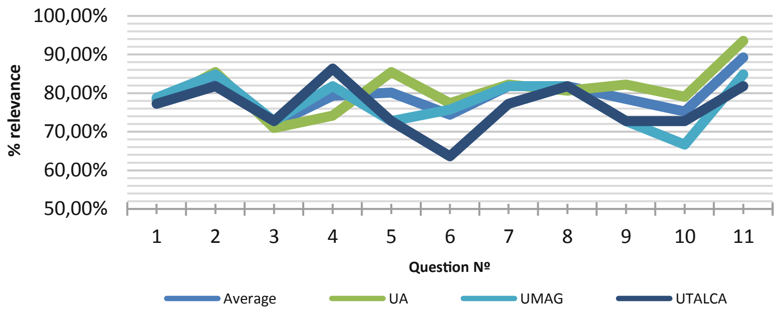

Fig. 3. Relevance of the different aspects consulted on "the strengthening of teaching methods" by University

Deeper data analysis and the classification and organization in categories related to the strengthening of teaching methods are presented in Fig. 3. The results obtained in 11 questions about teaching methods considered as the most relevant: "*Design, choice, and use of didactic means*", "*Use and development of new didactic means in the training of engineers*" and "*Planning and structuring of teaching-learning processes at university level*" among others. All of them with more than 80% of preferences [8].

Development of a Needs-Based Training Program on Engineering Pedagogy. The training program was designed by the Department of Professional Development, Training, and Certifications of CIEI and supported by the Chilean National Section of IGIP, both at the University of Talca, Chile. This training program seeks to promote the field of Engineering Education and to improve the qualification profile for teachers and trainers in engineering education based. The main educational objectives of the training program in Engineering Education are:

1. the development of pedagogical competencies of teachers and trainers in engineering education,
2. the improvement of teaching and learning methods and evaluation methods in technical subjects,
3. the development of practice-oriented curricula that correspond to the needs of students and employers, strengthening the university-industry partnership and collaboration,
4. the development and strengthening of research and innovation skills,

5. the acquisition of theoretical-practical knowledge about curriculum development and design,
6. the promotion of the use of media in technical teaching, and
7. the development of communication skills and strategies for face to face and distance learning.

Figure 4 summarizes the general structure of the training program. The whole training program will be carried out through a Blended Learning modality: including classroom sessions (face to face) and remote learning (e-learning) through a digital platform. Other online tools to improve communication and to provide feedback are considered. The training program contemplates a total of 600 h of classroom activities and e-learning, including lectures, workshops, short reports, and presentations, among others.

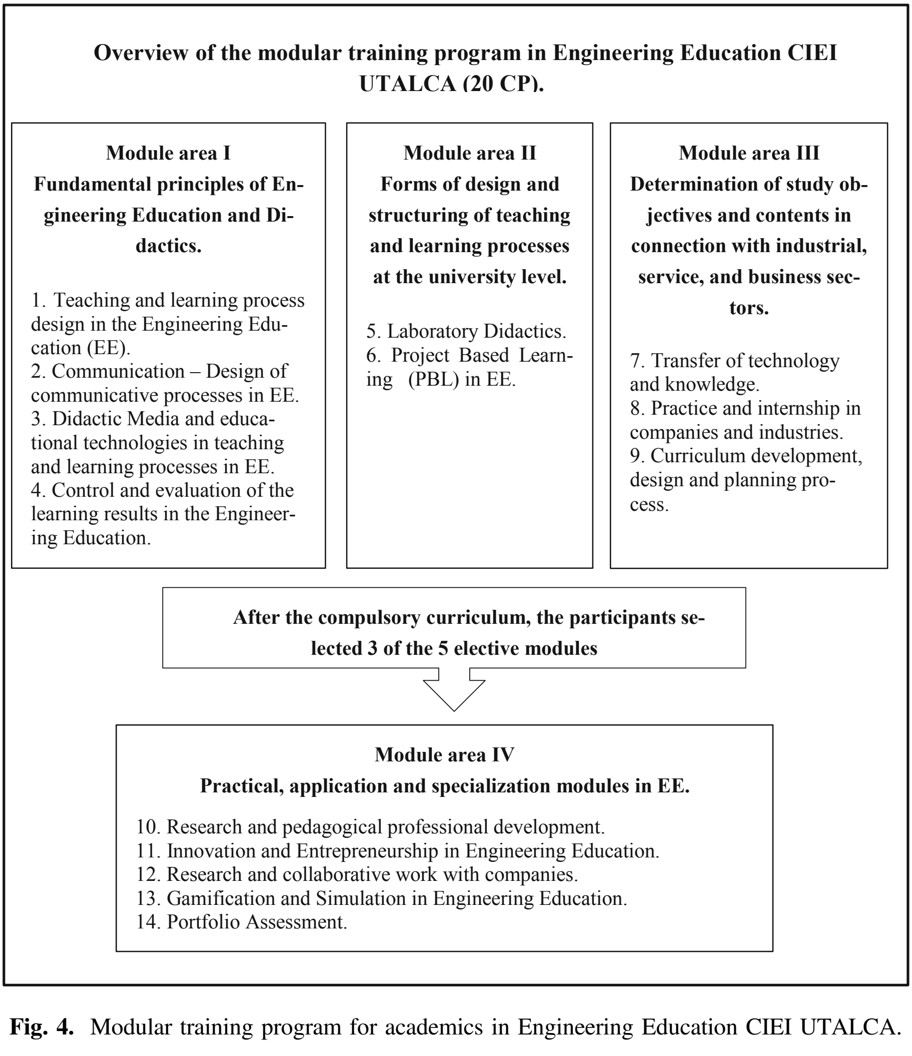

Fig. 4. Modular training program for academics in Engineering Education CIEI UTALCA.

4 Conclusions

Considering the experiences at the University of Talca and the results of the CIEI activities, it is possible to conclude, that the academic staff of Chilean engineering faculties, tend to converge on the specific needs for the engineering education, which come for example from fields such as the engineering sciences, the technological development and the new characteristics of the students of the 21 century. To meet these and other needs, it is necessary to develop and implement specific training programs for the academic staff in engineering fields. With these actions it is expected: (1) to increase the academic success of the engineering students and their participation at the social, economic and production sectors of the country; but also (2) to develop and improve the pedagogical competencies of the teachers and academic staff of engineering faculties, through the work of this kind of educational center on engineering, as CIEI.

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Features of the System of Advanced Training and Professional Retraining of Educators of Higher Technical Schools in Modern Conditions

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Abstract. The conceptual provisions of professional retraining and advanced training of educators of engineering universities have been formulated. It is shown that the system of pedagogical competencies is a main indicator of the activities of a modern educator. Requirements for the competencies of educators of engineering universities are formulated in accordance with the criteria of the International Society for Engineering Pedagogy («Internationale Geselschaft für Ingenieur Pädagogik»/«International Society for Engineering Pedagogy» (IGIP)). It is shown that the professional and pedagogical competence of a university's educator is an ability to apply knowledge, skills, personal, social and methodological skills in an educational or work situation in professional and personal development is the result of the development and assignment of universal, general professional and special professional competencies to students. Engineering pedagogy is presented as the basis of the system of professional retraining and advanced training of educators; the main trends of its development are outlined. The goals, content and structure of the professional-pedagogical activity of educators are considered, the priority components of their professionalism are identified. The advantages of the proposed organization of vocational retraining and further training for educators of engineering colleges and the organizational and pedagogical conditions ensuring the effectiveness of their vocational and pedagogical training have been identified.

Keywords: Professional pedagogical activity · Professional pedagogical competence

1 The System of Professional Retraining and Advanced Training of Educators of Engineering Universities

1.1 Conceptual Provisions for Professional Retraining and Advanced Training of Educators of Engineering Universities

By implementing of professional retraining (PR) and advanced training (AT) for the educators of engineering universities, we are based on the following conceptual

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provisions [2, 3]: 1. In the educators' PR and AT system, his professional competence is determined by fundamental engineering training, taking into account modern innovations in the vocational education system and professionally-oriented psychological and pedagogical training. 2. The goal of PR and AT of educators is based on the general goal of engineering education, the goals and objectives of the university development program, its priority area of development, the psychological and pedagogical training of the educators is integrated into the engineering education system, supplementing and developing it. 3. Every educator of engineering university needs a system of professional-pedagogical retraining, which contains a special professional orientation towards specific types of pedagogical activity, its functions, and the tasks that an educator decides to prepare for a future specialist. 4. The system of pedagogical competencies is a main indicator of the activity of a modern educator. 5. The main methodological principle underlying the functioning and development of the PR and AT system of educators is the principle of compliance of the system with changes in science, methods, technology and, accordingly, in the professional activity of an engineer and the professional-pedagogical activity of an educator. 6. The content of PR and AT of educators is based on the idea of integrating various fields of knowledge that are part of the field of their professional activity. This ensures the assimilation of systemic knowledge, the development of systemic thinking while saving training time. 7. The integration of psychological-pedagogical disciplines is defined as the highest form of expression of the unity of their goals, principles, content, methods, forms of organization and teaching aids.

Fundamental changes in engineering education, new forms of integration of science, education and production, an increased need for specialists with a high level of professional competence have caused corresponding changes in the system of PR and AT of educators of engineering universities.

The training of an educator of a technical university in the new conditions of introducing the institute of leading universities (national and federal universities, national research universities) in order to implement the educational program includes the identification of the relationship between scientific research and the educational process; the possibility of using your own scientific work as a means of improving the educational process.

The system of training and retraining of educators in the new conditions should ensure the coincidence of the development vectors of educators and specialties (disciplines), thus the educator at this stage of personal, professional development should make the maximum contribution to the development of the specialty and the training of specialists in it. Compliance with this requirement becomes possible if the educator is familiar with the methods of scientific research in the field of specialist training, able to transform scientific results into educational material, successfully apply computer technology and information technology in educational and scientific processes; own a foreign professionally-oriented business language.

1.2 The Competence of Educators: Main Ideas and Methodology of Development

The system of pedagogical competencies is a pivotal indicator of the activities of a modern educator.

The methodological and theoretical foundations of the development of educators' competences in the process of PR and AT are social, economic, psychological, didactic laws; main trends in the development of vocational education (humanization, democratization, integration, differentiation, intensification, cooperation), the main functions of the theory of scientific management. Justification of the methodology for developing the competence of educators in the AT-process, developing a model, methodology, designing technologies for developing their competence [4–9] are urgently needed by university theory and practice, since they need replacing the authoritarian strategy of professional training with a personal-improving strategy.

The content of the training is pedagogically based theory, logically ordered and pointed in the training documentation (program, textbook) scientific information about the material to be studied. In contrast to the content of training, which is a system of educational information that determines the content of the educator's educational activity and the cognitive activity of students, the content of education is the level of development of a person, subject, social, intellectual competence of a person. It is formed in the process of performing educational and cognitive activity and can be fixed as its result at a given time.

The content of education determines the key and special competencies, those personal and professional qualities that should be formed in the preparation process. It constitutes a system of competencies that are determined by the requirements of society and to the achievement of which the efforts of educators and students should be directed. Obviously, with the same content of training, curricula, programs and textbooks, students receive different levels of education. It depends on many factors: individual educational needs and capabilities of the listener; the level of its cognitive activity and self-sufficiency; quality of educational and methodological support of the educational process; personality of the educator, teaching and learning technologies, etc.

In modern conditions, the requirements for the quality of professional activity of educators are increasing. The new education paradigm strengthens the desire for professional success, actualizes the individually-creative beginning, increases the importance of the design and research competencies of the educator. At the same time, the personal and professional development of the university educator is considered as his self-realization, an awakening to creativity, the need to design his own professional level at various stages of his life. In professional self-improvement, it is necessary to rely on a high level of self-motivation of professional activity; the educator himself controls his professional self-development and self-improvement, where professional training is based on humanitarian knowledge, high professional culture, philosophical methodology.

Postgraduate education of university educators is currently carrying out intensive development of a methodology for the advanced education of university educator as an adult [7, 9]. This is due to the fact that the labor market begins to raise the bar of requirements, explores the possibilities of self-development of the individual and throughout life in the system of continuing education. Putting the study of factors influencing the increase of professional development reserves and their further practical implementation as its main task, advanced education synthesizes data around the key concept of "educator's resources". This allows you to analyze the conditions conducive to the long-term effective functioning of the educator in the profession.

Along with the high level of subject-specific industry competence of educators, their readiness for the implementation of educational and methodological functions in the context of the transition of Russian education to European quality standards is assumed. Changing the paradigm of the result of domestic vocational education (from defining level-wise requirements-goals to the preparedness of a future specialist for forecasting the competencies and competencies of a graduate) requires serious design and methodological work of educators. It includes goal setting in a new format (designing the content of subject competencies and competencies of students, including subjects in educational programs at various levels), reviewing the content of subjects, selection of pedagogically effective teaching technologies and quality control methods for developing competencies and competencies defined by programs. However, as our experience and the experience of many other researchers show, for many university educators, especially technical ones, these tasks are difficult to solve. The reasons are the lack of didactic preparedness of educators of technical universities, and the lack of traditions in the domestic technical higher school for designing educational and program documentation for academic subjects with the definition of the goals of their development of integrative results – professional skills and competencies, and the unresolved theory of concepts terminological issues. In addition, the role of the PR and AT system (APE system) in the context of these problems has not yet been rethought.

Analyzing the above said, we can conclude that the PR and AT system (APE system) of university educators has great potential in terms of the development of abilities, personal qualities, knowledge and skills of educators. This potential has not yet been sufficiently exploited, as extensive systems, traditional methods used mainly in higher education are mainly widespread in this system. In the context of the transition to a new education paradigm, these approaches lose their relevance and need to be replaced.

1.3 Engineering Pedagogy as the Basis of the PR and AT System (APE System) System of Educators

The professional pedagogical activity (PPA) of the educator of an engineering university is based on technical and pedagogical knowledge. The technical knowledge is becoming the systems which takes part of society more and more: the progress of technology through skills and ability to use it becomes one of the determining factors and conditions of spiritual wealth, the development of an aesthetic attitude to reality. It is obvious that in the structure of technical knowledge (except for natural science, social, technical, socio-technical) engineering and pedagogical knowledge is highlighted as a variety of socio-technical knowledge. Pedagogical knowledge as an open system has "access" to all types of human activity. It is an integral part of organizational, economic, socio-economic activity. This contributes to "the pedagogization" of all areas of society.

Psychological and pedagogical sciences focus on the objective laws of the knowledge of animate and inanimate nature. They are acquired in the process of studying such disciplines as cybernetics, ergonomics, engineering psychology and engineering pedagogy (EP) [10].

The didactic pentagram of EP [11] is the basis of the main pedagogical competencies of educators of engineering universities along with special competencies that ensure effective teaching of engineering disciplines. The basic didactic model of EP [11] follows the principles of the iterative process, being a universal tool for developing a curriculum, educational course in order to effectively teach engineering specialties. The implementation of the integrated four-component model of teaching EP [11] as the basis for developing an integrated course that takes into account the basic theories of education, preliminary knowledge and characteristics of students is one of the prerequisites for effective teaching and a prerequisite for the formation of the expected pedagogical competencies of educators of engineering faculties. The pedagogical competencies of educators are becoming increasingly important in assessing the quality of engineering education. The modern approach to teaching involves not only teaching students engineering knowledge and skills within the framework of the specialty, but also developing their technical, logical, creative and critical thinking skills, as well as problem-solving skills, joint learning, communication, achievement of values, development support personalities that are, without exception, the key. The most effective basis for continuing education for educators of engineering faculties is EP – a science that offers suitable and relevant didactic models for effective planning, training, and also for a comprehensive, integrated course design based on informed decisions, learning analytics, reflection and metacognition.

One of the main tasks of EP has always been the development of a scientific methodology for the training of educators of technical universities. The need to form demanded competencies among students requires continuous training of educators of engineering and humanitarian disciplines of technical universities. In response to this challenge, in recent years there has been a tendency for the rapid development of short-term highly targeted diversified courses designed for different target groups of students [12].

We also emphasize that in the context of the increasing use of electronic and distance learning, leading to a reduction in the time of direct communication between students and educators, the process of educating the future engineer, shaping his personality, and not just training highly qualified workforce, is of particular relevance to the educator.

Currently, the development trends of EP are determined by the need to overcome the contradiction between the rapid changes in the conditions of professional activity of engineers and the well-known conservatism, inertia of the engineering education system. In this regard, we can talk about several main trends in the development of EP [12].

1. The rapid changes that are taking place in society at present require regular updating, specification and forecasting of the goals of engineering education, a description of the planned learning outcomes.
2. Today, a search for new forms of training is being carried out in order to bridge the gap between the changing requirements for the professional activities of engineers and learning outcomes. At the same time, training forms implemented by universities in close collaboration with researchers, business and industry are becoming increasingly important. The development of new technologies and training methods using information and communication technologies, multi-media, and the introduction of adequate material and technical support and software products into the educational process are ongoing.
3. Regular changes in the educational process under the influence of the introduction of new versions of state standards, accreditation rules, which entails the modernization of curricula and programs are making the engineering education system more unstable. Taking into account that this process is due to objective reasons related to changes in society, it can be assumed that this trend will increase.
4. The necessity of constantly improving the skill of educators of technical universities and of increasing their pedagogical qualifications in these conditions requires the rapid development and implementation of a variety of narrowly targeted diversified courses that focus on the needs of specific target groups.

2 Professional-Pedagogical Activity: Goals, Content and Structure

2.1 Goal of Professional-Pedagogical Activity

The teaching and methodological knowledge of the structure, logical organization, methods and means of activity as a system of principles and methods of its organization and construction are the methodological basis for the study of PPA.

Methodological knowledge allows you to deeply penetrate the essence of internal and external contradictory PPA; determine its goals, object and subject as system-forming factors; to come up with a unified theory of describing the content and structure of PPA. The content of the PPA is reflected in the "technological" basis of the educator's work; through it, the basic functions and the solution of a whole complex of educational tasks, the socio-pedagogical, socio-psychological and spiritual interaction of the educators and students are realized. The consideration of the PPA from the content side implies the actualization of those competencies that are outside its subject area, but are associated with them and are needed to perform various functions (design, constructive, gnostic, communicative, organizational), as well as to explain educational and psychological phenomena of educational process.

On the part of functions, it allows one to substantiate their composition, to distinguish structural and functional components from them, to correlate them with pedagogical skills, which are the "cell" of professional pedagogical activity and act as if it were a micromodel. On the part of educational and educational tasks, it allows us to subdivide them into subject, interdisciplinary, complex, including didactic (aimed at achieving educational goals) and educational (aimed at achieving educational goals).

The central component of the PPA is its objectives. They are determined by the general goal of engineering education and the goal of training specialists for a specific area of professional activity. Objectives are reflected in the curriculum for each academic subject. Summarized, they can be expressed in three theses: the formation of a system of scientific knowledge and skills; the formation of professional activities (professional skills); education of the specialist's personality by means of the studied discipline, pedagogical activity in general and the personal potential of the educator.

The goals of the PPA are realized through the organization of educational, scientific and industrial activities of students as a single process in which knowledge, skills, capacities, abilities to perform gnostic, design, constructive, communicative and other functions, to solving problems with industrial content. The ultimate goal of the educator's PPA is set by the ultimate goal of training a specialist – professional competence, readiness for innovation.

The essence of advanced training is globally defined in the advanced training (principle of double advancing) of scientific and pedagogical staff (SPS), the meaning of which is not so much to saturate the listeners with a certain amount of information, but to develop such skills as the ability to operate with information, design and model their activities.

For the APE system, focused on the personal and professional development of the educator, the value-semantic orientation of the PR and AT processes is decisive. All these changes quickly increase and call into question the traditionally understood professional and pedagogical competence of the university educator. In modern conditions, a steady competency of the educator is needed, which he develops in the process of advanced training and self-education.

2.2 Priority Components of Educator's Professionalism

In general, the pedagogical professionalism of an educator in higher school should be considered as an integrative property of a person, combining the entire scientific and educational activities of an educator, acting as a complex of psychological and pedagogical competencies, expressed in his ability and willingness to effectively solve the problems of professional activity [8].

In recent years, in our country, there has been a reduction in the centers and institutes of teaching and learning programs for educators, as a result of which some significant scientific and practical achievements of Russian scientists in the field of education have been lost. At the moment, the situation is such that the vast majority of educators of technical disciplines do not have professional psychological and pedagogical training, do not have the basics of didactics, the methodology and methods of teaching the practiced field of scientific knowledge.

Programs of psychological and pedagogical training are short-term (from 16 to 72 class hours) and do not have the resource to fully support the process of forming the necessary complex of professional and personal psychological and pedagogical competencies among higher school educators. It is possible to solve this problem only if a new effective system of vocational education for university educators is created, the main component of which is the psychological and pedagogical software programs in integration with a group of APE programs in those scientific areas that meet the interests of existing university educators.

All existing and positively established forms of SPS are united by a common methodological principle - the leading nature of the scientific justification of the educational process of future educators of higher education. The system of PR and AT for university educators is designed not only to adequately to changing socio-economic conditions, the needs of society and the state, but also to determine promising areas for the development of industry, information technology, etc., therefore, provide advanced training for educators of technical curricula disciplines, providing them with conditions for continuous self-development and professional self-improvement. Two priority components should be singled out as main components of the professionalism of university educators: the personality of the educator as a carrier of cultural socio-historical experience and the educator as a resource of scientific knowledge for students. In the first case, the educator, being in constant and continuous interaction with students, through the prism of his personality, through his behavioral manifestations acts as a model for the formation of worldview, values and value orientations, social norms for students. In the second, he acts as a translator of knowledge and skills in a particular scientific and professional field. Before the educators of specialized graduate departments without basic professional psychological and pedagogical education in the process of implementing educational work, a complex of problems appears immediately, both educational, and didactic and methodological in nature. These problems are related to the subject activity of educators and reveal the formation (or lack of formation) of his professionally significant personal qualities. The problem of the complete absence or insufficiency of psychological, pedagogical, didactic and methodological preparedness of educators of engineering universities is obvious: many teach their subject based on randomly and spontaneously formed knowledge and personal experience of themselves as students, copying and imitating their educators. This does not always meet the scientific foundations of psychology and pedagogy, as well as the methodology of teaching disciplines. This situation invariably negatively affects the quality of the educational process at the university, i.e. on the training of future engineers. From this problem, the following arises: how can the management and administrations of universities assess the degree (level) of professional readiness formation, the professional suitability of scientific and pedagogical workers for teaching, for educational work with students.

The scientific effectiveness of the educator can be determined by analyzing a number of real indicators: his publication activity, the availability of a degree (candidate of sciences, doctor of sciences), title (associate professor, professor), participation in research projects, in international and scientific and practical conferences, work on the management of scientific and qualification work of masters, graduate students and applicants and other criteria.

The effectiveness of teaching is possible to see through an analysis of the quality's work of training. The following criteria should be singled out as basic criteria for assessing teaching activities [8]: correspondence of the educational program to the topic of a lecture or practical lesson in the taught discipline to the curriculum; correspondence of the educational program to the topic of a lecture or practical lesson in the taught discipline to the curriculum; the presence of a lesson plan, logical completeness in the presentation of each separate topic, each lecture question, practical assignment - the entire set of educational material; monitoring, integration and development of existing knowledge of students in the context of a new educational material; the presence of interdisciplinary relations of the taught discipline with other subjects studied by students and already existing knowledge; deep scientific knowledge in the field of the material presented; knowledge of the terminology of the taught discipline; determination of conclusions on each issue of discipline; ability to actively apply innovative technologies and modern teaching aids; the formation of a educator's behavior culture: skills of oratory, pedagogical tact, self-determination of oneself as an educator, observance of subordination, manifestation of tolerance and respect for students, manifestation of a humanistic approach to everyone, etc.; conciseness, rationality and accessibility of the presentation regarding the level of intellectual and educational preparedness of the contingent of students; implementation of student motivation techniques to educational activities; self-discipline, control and correction of student behavior; establishing feedback with students; assessment of students' learning of taught teaching material; analysis and assessment of their own educational activities and the work of colleagues.

2.3 Advantages of the Proposed Organization of PR and AT of Educators

Educators without basic psychological and pedagogical education can learn all the above professional knowledge, skills during the professional retraining under the programs "Psychology of Professional Activities", "Pedagogy of Higher Education", "Engineering Pedagogy" (each program has over 250 class hours), as well as according to qualification improvement programs of various professional orientations (from 16 to 72 h) implemented at our university [2, 3, 13].

Curricula suppose a modular basis, and the final certification of students is carried out in the form of a final interdisciplinary exam or defense of the final certification work. The content component of module disciplines is updated and adapted in accordance with new rational and promising trends in education.

The learning process for these programs has several advantages: the productive nature of the practical scientific and educational activities of students – future educators of higher education: students have the opportunity to take training on a flexible class schedule without interruption from their main professional activity; future educators incorporate the acquired knowledge into their teaching activities in practice; current educators of specialized curricula disciplines of universities bring out problems (that they have in practice when working with students and in their scientific activities) for discussion in practical classes.

The students complete individual tasks aimed at solving a specific methodological problem. As a rule, these projects are problem-oriented in nature and, based on the results of their implementation, are introduced into the practice of the educational process of the department. University educators modernize the documents of the educational and methodological complex of disciplines, develop materials for the assessment fund, plan the content and organization of students' independent work, design sections of educational publications, master e-learning technologies, create electronic educational resources, etc.

The following should be mentioned as proven students in the training of additional educational programs of RT and AT: relevant forms of training: case-study method, problematic online lectures, research seminars, webinars, socio-psychological trainings, laboratory workshops, master classes, project discussions, scientific and practical consultations; modern teaching aids: network and local information networks, digital resources of a new generation, a mobile fund of assessment tools, etc.; interactive methods: inter-university online discussions, problem-oriented training, interdisciplinary projects, network and online training, etc. [14, 15].

Organizational and pedagogical conditions that ensure the effectiveness of the process of professional and pedagogical training of educators of engineering universities include: the formation of internal intentions among students for constant, continuous professional and comprehensively personal self-development through reflection on their professional activities; the implementation of training of scientific and pedagogical staff on the basis of integrative, competency-based and personal-social-activity approaches; providing informational and methodological support for the process of professional psychological and pedagogical training of students.

The problems of training of educators are were research by scientists from different countries. One of the leading places is occupied by IGIP. Under the auspices of this organization, in our country Centers of Engineering Pedagogy (CEP) were organized and accredited, in which educators with technical education can receive the IGIP diploma “International Engineering Educator ING.PAED.IGIP”, which is recognized in 38 countries of the world after successful training in the program “Engineering Pedagogy”.

Our university has 25 years of experience in implementing the additional program of the educational program “Pedagogy of Higher School” for obtaining the additional qualification “Educator of Higher Education”. Since 1994, about 1,600 educators and employees of universities and colleges have passed PP. The asset has been accredited by the international society for engineering pedagogy IGIP CIP for more than 20 years of experience in implementing the program “Engineering Pedagogy’ to receive the international IGIP diploma “International Educator in Engineering University”. Since 1997, 116 educators of engineering universities in Russia have been trained.

An analysis of the assessment criteria for a modern educator of an engineering university made it possible to determine the complex of the following requirements for an engineering educator [1, 8]: continuous self-development and deepening of knowledge in the field of taught disciplines of a technical orientation; continuous improvement and professional development, both in the field of technical education, and psychological and pedagogical; development and implementation by educators of engineering universities in educational practice of curricula of an integrative, interdisciplinary nature, meeting the interests of both students, employers, and various state social institutions and industrial sectors; active use in their teaching activities of innovative forms of training for future engineers; updating the content and increasing the hours of disciplines of the humanitarian block in technical universities; formation of a special consciousness among students as future engineers; formation of a culture of behavior in accordance with the standards adopted in this social environment;

development of an “ecological worldview” among future graduates of a higher technical school.

The level of professional and pedagogical culture of educators of an engineering university is in many ways determined and laid down in the process of training under the programs of the psychological and pedagogical profile. This stage of their formation as educators is empirical. Then they put into practice the theoretical knowledge gained in the fields of pedagogy, psychology, didactics, teaching methods, and the experience of other colleagues – the stage of pedagogical practice. It is possible that students researched these stages during of studying at the master’s or postgraduate courses according to the profile of their scientific and technical field of activity, but provided that humanitarian programs with a psychological and pedagogical component were present in these programs.

Passing these two stages forms the professional and pedagogical minimum (the basic level of professional skill) that every educator who actively interacts with students and realizing himself in the research field.

The modern paradigm of higher education necessitates special training for educators. It is obvious that training integrating technical, technological technical and human knowledge in the field of pedagogy and psychology and meeting the requirements of engineering and pedagogical activity, as well as engineering training, need further development of methodology and theory.

3 Conclusion

1. New forms of integration of science, education and production, fundamental changes in engineering and engineering education have caused corresponding changes in the system of teaching and learning for educators of technical universities.
2. An important role in engineering activity and engineering education is played by engineering pedagogy, the subject of which is engineering education as a development of experience in engineering activities.
3. The modern paradigm of higher education necessitates special training for educators. It is obvious that training integrating technical, technological and human knowledge in the field of pedagogy and psychology and meeting the requirements of engineering and pedagogical activity needs further development of methodology and theory.

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IGIP Prototype Curriculum, Teachers' Professional Development and Distance Education in Russia During COVID-19 Pandemic

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Abstract. IGIP Prototype Curriculum pays special attention to the development of the ability of engineering university teachers to use effectively technical aids, information and communication technologies (ICT). In Russia, there are various additional professional programs for the same purpose. The outbreak of COVID-19 pandemic caused closures of engineering universities of many countries including Russia for the spring semester 2020. Since the end of March 2020 in Moscow Automobile and Road Construction State Technical University (MADI), all the teaching has been taking place remotely/online. The situation of this large-scale natural experiment gives the opportunity to analyze its results and to try to find answers to numerous questions. The paper is devoted to the survey of the attitude of MADI foreign language teachers and students towards distance learning technologies. The survey identifies the distance technologies used, the opinion of the respondents of their efficiency, the difficulties the respondents faced during remote educational process, the respondents' opinion of the prospects of distance technologies in foreign language training, the differences and similarities of the attitudes of foreign language teachers and students.

Keywords: IGIP Prototype Curriculum · Teachers' professional development · Distance education · Foreign language teachers and students' survey

1 Context

One of IGIP aims is improving teaching methods in technical subjects in engineering universities. Its achievement greatly depends on the qualification of technical teachers. For teachers' professional development, the Society created IGIP Prototype Curriculum with its versions for different time.

All the four versions of IGIP Prototype Curriculum were designed in different situations but all of them paid special attention to the ability of a teacher to use technical aids in the educational process. The First IGIP Curriculum was created by A. Melezinek in the 1970s. One of the subjects of the Curriculum was "Fundamental Principles of Educational Technology" (24 h). Its aim was to help teachers to use

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effectively technical devices, equipment, and systems, including both "classical" equipment (blackboards, overhead projectors, slides, film projectors, etc.) and the so-called "new media" (computers, video cameras) [1].

The Second IGIP Curriculum (2005) contained the discipline "Media, E-learning and Computer-aided Technologies" (2 CP). The aim of the subject was to develop the ability to use the "classical" teaching media, to know the function, operation of "new" teaching media and to use adequately and create "new" devices, for example, advanced learning platforms, various forms of internet communication, to plan the didactic concept of notebook classes, explain and use databases, etc. [2].

The Third IGIP Curriculum (2013) followed the tradition and included the module "ICT in Engineering Education" (1CP) [3]. After the course the teachers are supposed to be able to identify, to select, to design, to produce, and to use the most appropriate IC technologies or their combination for specific instructional needs in the educational process, for example, for presenting information or communicating with learners. The course covers the issues of electronic learning, internet searching, e-learning/blended learning, communication services and tools, Learning Management Systems (LMS), Content Learning Management Systems (CLMS), SMART technologies, structure and organization of an electronic course, methodology ofcourses, didactic approach to creating scenarios and structure of an e-course, measuring the effectiveness of an e-course. At present, the Task Force is developing the Fourth IGIP Prototype Curriculum and after its approval, many countries will introduce it in Engineering Pedagogy Centers.

In Russia, besides IGIP Engineering Pedagogy Centers, the courses connected with modern ICT technologies, are implemented within the programs of professional retraining for the qualification "Teacher of Higher School" or as short-term programs of teachers' professional development (min.16 h).

The aims and content of the disciplines for the development of didactic competence of teachers in the sphere of ICT are becoming more and more informative and complicated due to the fast changes in this field. Thus, Russian university teachers have the opportunity to improve corresponding habits and skills. The level of the teachers' skills vary from highly advanced ones to rather low ones. However, due to COVID-19 pandemic all of the teachers had to use the acquired skills quite unexpectedly, at a large scale and at least for the period of a term.

2 Goal

The outbreak of COVID-19 pandemic caused national shutdowns and temporary closures of schools, colleges, and universities. The process began in China in February 2020. Later engineering universities of Italy, Spain, Switzerland, France and other countries had to suspend all of their face-to-face teaching activities for the duration of the spring semester 2020. All the teaching has been taking place remotely/online. In the Russian Federation, engineering universities closed at the end of March. The RF Ministry of Higher Education and Science recommended using distance-learning technologies and open educational applications and planforms to reach learners remotely.

The achievements in e-leaning and distant learning have allowed engineering universities to maintain educational process in the period of COVID-19 pandemic. Russian engineering universities could use Moodle, Google Classroom, and Blackboard as learning management systems to help document, administer and track the educational process. It was possible to use various software: Zoom, Skype, Microsoft Teams, and Google Hangouts as communication tools. The choice of the systems to use depended on the University.

MADI recommended the teachers to use Microsoft Teams. Three days after the switch to distance education the teachers and students received instructions and passwords for the access. Up to now, all the teachers have acquired unprecedented two months experience of distant education. We found ourselves in a large-scale natural experiment. It is necessary not to lose the opportunity to analyze its results and to try to find answers to numerous questions.

One of the questions is connected with the opinion of teachers and students about distance learning. Many educators think that the attitudes of teachers and students towards distance learning are different. They assume that students are eager to switch to distance technologies, and that the teachers are more conservative in this matter. Thus, our goal was to verify this hypothesis, to identify the attitudes of teachers and students towards the distance technologies used and compare them.

3 Approach

In order to achieve the goal and verify the hypothesis mentioned above, a survey method was used. The primary questionnaire method was elected [4] as it has a number of evident benefits. It does not require special training of the interviewers, gives rather accurate results, etc. The questionnaire survey technique included the following stages: preparation, factual data collection, and analysis of the information obtained.

The objectives of the survey were to identify:

- the distance technologies used;
- the opinion of the respondents of their efficiency;
- difficulties the respondents faced during remote educational process;
- the opinion of the respondents of the prospects of distance technologies in foreign language training;
- differences and similarities of the attitudes of teachers and students.

At the preparation stage, two questionnaires were compiled. One of them was intended for teachers and the other one – for students. Both questionnaires consist of three sections: an introduction, factual information, and the basic part. The introduction of the questionnaire reveals the purpose of the interview and instructions for its filling in. The factual information of the questionnaire contained facts concerning the respondents' age (teachers) and the Department (students). In the basic part both questionnaires included the same semi-closed type questions concerning the distant technologies the respondents used and their opinion of their efficiency, the difficulties they had, and the prospects of future distant technologies implementation. The teachers' questionnaire contained one additional semi-closed question on the skills the teachers had acquired and an open question concerning the value of the acquired experience. Both questionnaires contained an open question to find out the respondents' opinion on the prospects of distant technologies implementation.

The second stage of the survey involved data collection. The survey was organized by the Department of Foreign Languages of MADI in May 2020 and embraced all the teachers of Foreign Language Department (45 teachers) and all the students of the program "International Transport Policy" (four groups, 45 students) who had regular English webinars via Microsoft Teams and attended them regularly.

At the third stage of the survey, the analysis and generalization of the information took place.

4 Actual Outcomes

According to the survey data, the teachers used various technologies of distance education: Microsoft Teams – 60%, ZOOM – 11%, Skype – 26.7%, WhatsApp – 57.8%, chats – 15.5%, e-mails – 100%. The results show that not all the teachers but only 97% of them managed to organize webinars, but all of them used e-mail for corresponding with students. The variety of tools for webinars may be explained by the fact that the teachers had the opportunity of choice. Those who used ZOOM or Skype responded that these tools were easier for them to use than Microsoft Teams.

The students also used various technologies: Microsoft Teams – 100%, WhatsApp – 66%, chats – 6.6%, e-mails – 28.6%. They did not use Skype and ZOOM but only Microsoft Teams as this tool was chosen by their language teachers and was the only way for them to attend webinars. It may be assumed that Microsoft Teams were used for correspondence with teachers as only 28.6% of students used e-mailing.

As far as the opinion of the teachers of the most effective tools is concerned, e-mail takes the leading position (64.4%), then come Microsoft Teams (53.3%), WhatsApp (31.1%), Skype (17.8%), chats (6.7%), and ZOOM (4.4%). The qualitative analysis showed that almost 90% of the teachers who used Microsoft Teams consider this tool most effective.

The students also consider Microsoft Teams to be most effective (100%), then comes WhatsApp (37.4%), e-mails (4.4%), and chats – 0%. ZOOM (0%) and Skype (0%) are not considered effective as the students did not use them. One of the students expressed the opinion that though Microsoft Teams were reliable he prefered Google Classroom because it gives the opportunity to have one common disk to display lectures and home tasks, to have chats, and it is possible to use it with any gadget you have.

The teachers had many difficulties connected with distance education. They had the following problems (in some cases the sum is more than 100% because it was possible to choose more than one answer):

- non-stop work with a computer – 64.4%,
- greater fatigue in comparison with face-to-face studies – 64.4%,
- technical problems – 62.2%,
- absence of direct contact with a teacher and students – 57.64%,

- a larger volume of preparatory work – 37.8%,
- impossibility of putting clarifying questions – 37.8%,
- difficulties connected with remote communication – 33.3%,
- difficulties of workplace organization at home – 20%,
- no problems at all – 0%.

The students also faced various difficulties while distance learning:

- technical problems – 57.2%,
- non-stop work with a computer – 37.4%,
- the absence of direct contact with a teacher and students – 35.2%,
- a larger volume of self-study work – 26.4%,
- difficulties connected with remote communication -22%,
- difficulties of workplace organization at home – 17.6%,
- impossibility of putting clarifying questions – 13.2%,
- greater fatigue in comparison with face-to-face studies – 8.8%,
- no problems at all – 8.8%.

The comparison of the results shows that both the teachers and the students have similar difficulties with almost similar relevance. Most of all both the teachers and the students suffer from the same difficulties: technical problems (62.2% and 57.2% respectively) and non-stop work with a computer (64.4% and 37.4%, respectively), the absence of direct contact with a teacher and students (57.8% and 35.2%). The rating of other problems also coincide. However, the teachers have more difficulties than representatives of "digital natives" generation do. The teachers find almost 1.5 times more difficulties than the students do (144 answers of the teachers compared to 99 answers of the students). Even 8.8% of the students think that they did not have any problems at all. At the same time, there are no teachers without any problems. The greatest difference is connected with the fatigue of distant technologies users. 64.4% of the teachers note it and this difficulty takes one of the two leading positions in their answers, whereas only 8.8% of students feel fatigue.

The teachers' questionnaire included the question if the teachers managed to acquire valuable technical skills of distance education. The students did not have this question as they have a high level of this competence. 68.8% of the teachers confirmed that they had acquired these skills. 37.8% of them had improved the skills but they did not consider them sufficient, 31.1% had improved the skills considerably, 13.3% managed only to maintain the level they had already had, 8.9% had improved the skills but they would like to take another specilizedcourse. 8.8% of the teachers had not improved the skills for two different reasons: 4.4% failed to do it and 4.4% had already a sufficient level.

Answering the open question concerning the value of the experience gained, the teachers enumerate a lot of various habits and skills. The main part of the teachers write that they have acquired valuable skills of using communication tools (Microsoft Teams or ZOOM); the ability to organize on-line individual self-study work of students, to use ICT for collection, demonstration and introduction of new material (video films, e-textbooks, testing, oral texts for listening). Some teachers underline that they have gained self-confidence in conducting on-line classes, the assurance that they need to improve their skills of distance education and the experience of adaptation to quite new conditions. Some of them consider it important, that they had the chance to have a closer communication with their students, to see them at home and that it contributes to better understanding between them, a friendlier atmosphere. Some teachers appreciated the opportunity to compare face-to-face teaching and distant teaching, to see the advantages and disadvantages of both. Some enjoyed the opportunity to communicate with students at any convenient time. Some of the teachers noticed that work had become more individual and the students had taken more responsibility. The teachers think that now they will participate more often in webinars of other universities and other countries.

Expressing their opinion on the prospects of distance education in foreign language training, the teachers think that:

- Elements of distance education are possible only in the cases they are more effective than face-to-face training – 51.1%.
- Completely distance education is possible only in case of necessity – 42.2%
- Distance education is possible only for individual consultations – 31.1%
- Distance education in foreign language training is not possible as it requires face-to-face contact – 15.5%
- It is better not to use distance education at all – 13.3%
- Completely distance education is necessary as it is more effective – 0%.

Unexpectedly the students turned out to be of almost the same opinion of the prospects of distance education in foreign language teaching:

- Elements of distance education are possible only in cases they is more effective – than face-to-face training. 41.8%
- Completely distance education is possible only in the case of necessity – 37.4%
- Distance education is possible only for individual consultations – 15.4%
- It is better not to use distance education at all – 8.8%
- Distance education in foreign language training is not possible as it requires face-to-face direct contact – 4.4%
- Completely distance education is necessary as it is more effective – 4.4%

The main difference is that 4.4% of students think that completely distance education is possible as it is more effective and no teachers think the same.

The teachers are sure that foreign language training aimed at teaching communication requires face-to-face classes. At the same time, they think that in the traditional course it is possible to use distance education technologies for individual work with students, management of their self-study work, for instruction of correspondence students, for inclusive education. Among the advantages of distant learning technologies, the teachers underline the opportunity to demonstrate video films, oral texts, to use language tests, to organize on-line conferences. They also think that students gain more responsibility working on-line. At the same time, they are sure that in this case it is necessary to introduce radical changes in the programs and teaching materials, to have reliable equipment for both teachers and students. It is also necessary to provide a course of further teachers' professional development oriented at particular electronic environment used.

According to the students' opinion, distant learning technologies used for the English course under the program "International Transport Policy" in the situation of coronavirus pandemic were successful. In spite of some technical problems, the students are sure that they managed to acquire the necessary language skills. They underline that distance education is possible only in cases of emergency. They write that in their opinion distance technologies are not appropriate for foreign language studies, as it requires face-to-face communication and very high quality of Internet to feel the peculiarities of pronunciation, to hear oral texts, etc. They note that for them face-to-face direct communication with a foreign language teacher and groupmates is of vital importance.

5 Conclusions

All variants of IGIP Prototype Curriculum paid special attention to the course of distance education technologies. In Russia, additional programs are provided for teachers' professional development in the sphere of ITC. Thanks to the acquired skills, Russian engineering university teachers have been able to maintain remote teaching for the spring semester 2020 caused by COVID-19 pandemic.

The survey undertaken in MADI at the end of remote educational process has not verified the hypothesis that the students are eager to switch to distance learning technologies while the teachers are more conservative about it. According to the results of the survey the attitudes of foreign language teachers and students towards the efficiency of distant communication tools, the difficulties the participants of the remote educational process meet, the prospects of distant technologies for foreign language training are similar. However, the teachers have more difficulties and suffer more from fatigue than the students who belong to the generation of "digital natives".

Both the teachers and the students recommend only elements of distant technologies for foreign language in cases they are more effective than traditional methods, as the discipline requires direct face-to-face communication. Distant technologies can be effective mainly for individual work with students.

Coronavirus pandemic has affected engineering education systems worldwide. The teachers including teachers of foreign languages have acquired valuable experience and self-confidence in using distant technologies. The experience of distance education during the pandemic will have a strong positive effect on the engineering education.

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The Improvement of Engineering Subject Didactics and the Didactic Abilities of Teachers for Teaching Social Sciences Students: Case of Engineering Graphics

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Abstract. The article presents the data of qualitative research and analyses factors of successful learning of the study subject of Engineering Graphics mainly focusing on external and internal motives. The article is grounded on the conception of constructivism and student-centred studies, which embrace the whole study system from the description of study subject to the student-teacher relation. The research results show that seeking for the success of student learning, it is firstly necessary to think over the formal requirements of the study subject of Engineering Graphics: the description of the study subject, the number of assignments, their content as well as the content of independent and contact work. Striving for successful process of teaching and learning, the teacher has to consider the specifics and tendencies of generation Z students. However, internal motives, which are related to the students' competence of learning to learn, and the teacher's didactic abilities are seen as the most important factors.

Keywords: Engineering subject didactics · Didactic abilities of teachers · Learning to learn

1 Introduction

This article relies on the theory of constructivism, which sets the sufficiently difficultto-achieve goal of creating individualistic reflections of the world based on personal experience rather than adopting and memorizing rudimentary and conventional knowledge. Learning should not be solely centred on observation, listening and feeling. Thinking structures, expanded by personal activity and experience, become a salient factor in the studying process. Often, this becomes a challenge for both the teacher and the student, especially in the process of developing engineering thinking structures. Upon analysing the engineering competences, it becomes evident that proper education in engineering is hardly possible without studies of Engineering Graphics. This study subject does not only foster logical thinking but also cultivates spatial intelligence and teaches to create and read technical drawing. Therefore, this subject is to be implemented in the study programmes of Engineering and Technological Sciences and Social Sciences in Vilnius Gediminas Technical University. If philosophy or leadership

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are the preferred study fields among students in Social Sciences, the discipline of Engineering Graphics is undoubtedly favoured among STEM students. It is consequently imperative that teachers understand the potential learning obstacles for students and constantly improve the didactics of the subject along with their own didactic capacity when teaching an engineering-oriented subject to students in Social Sciences. As P. Kukk et al. [5] argue, Engineering Graphics is not a very interesting subject to learn in itself. There is a large number of precise ISO and ANSI standards, among others, which must be followed in order to complete technical drawings properly. To stimulate student interest in targeted learning and balance this with the courses' learning outcomes, the following elements were introduced into the process of teaching and learning process: assignments aligned according to the Bloom's taxonomy; creative elements in assignments; continuous and formative assessment; two-phase feedback – individual and generalized; bonus points in grading procedures to reward particularly impressive homework; the lecturer's support for and focus on those elements of the course which were interesting to students; no dominance of drilling on ISO in the course; "external" motivators. Thus, the study subject of Engineering Graphics (6 credits) is taught to the first year students of the study programme Transport Engineering Economics and Logistics of the Faculty of Transport Engineering at VGTU. The analysis of the description of the study subject allows concluding that the learning outcomes of the study programme and the study subject are in line with each other and with the same level of the Bloom's taxonomy: the first one embraces the level of knowledge (the student will know….), the second level refers to applying (the student will apply theoretical knowledge of Engineering Graphics in practical works….), the third level includes the levels of analysing, synthesising and evaluating (the student will be able to analyse and critically evaluate the information). The study and assessment methods and three levels of achievements (threshold, average, excellent) are provided for each learning outcome. Engineering thinking of students in Social Sciences is developed and enhanced with the help of three parts of Engineering Graphics: drawing geometry, drawing and computer program AutoCAD. Engineering graphics is a usual component in various engineering study programmes but it does not mean that the main parts are always the same. K. Nabutola et al. [7] present the work of a team of researchers from five different universities, who have collaborated conducting research on the development of the engineering graphics concept inventory. A Delphi panel of graphics professionals succeeded in identifying 120 unique topics of important in the area of engineering graphics [11, 12]. Then these topics were categorized into 10 main concepts: Visualizing in 2D and 3D, Mapping between 2D and 3D, Planar Graphical Elements, Sectional Views, Methodologies for Object Representation, Projection Theory, Parallel Projection Methodologies, Drawing Conventions, Dimensioning and Solid Modeling Constructs. The topics of the study subject are arranged in accordance with the goal and the intended learning outcomes of the study programme. The lecturer should very carefully design each particular course taking into account the outcomes stipulated by the curriculum, students' preliminary knowledge and their different learning styles. Engineering Graphics is a mandatory subject for all the students learning science and engineering. The extent of this learning depends on their particular field of study [5].

2 Methodology

The methodological foundation of this article is the theory of constructivism and selfcentredness in learning. These two bases encompass the entire system: the compliance between the subject and result, the study content, the methods applied in the study process, the professional relationship between the student and the teacher. To conduct the qualitative study, the phenomenological research methodology was employed. This strategy is based on the attitude that people understand and perceive phenomena differently but ways of their understanding are interrelated. The goal of it is to present the variety of aspects that characterise the experience of specific phenomenon [15]. The aim of the article is to analyse the factors of successful learning of Engineering Graphics among students in Social Sciences emphasising external and internal motives. Seeking to demonstrate an in-depth understanding of the phenomenon, the purposive sampling was applied. The semi-structured interview was carried out within a group of 23 informants – first year students of Transport Engineering Economics and Logistics (Social Sciences). The interview questions focused on identifying students' prior expectations, involving/not involving topics of lectures, differences from other study subjects, advice to future first year students and teacher didactic abilities. Analysing the data, the descriptive categories and the outcome space of the concept, which manifests itself through the network of logically interrelated, hierarchical organised and systematised categories were employed [1, 10]. The underlying question of present research is: what factors of successful learning of Engineering Graphics can be identified among students in Social Sciences (Table 1).

3 Research Results

The Description of Study Subject. Referring to their expectations to learn the study subject of Engineering Graphics, the students of the study programme of Transport Engineering Economics and Logistics in the study area of Social Sciences emphasized their wish to obtain new skills, especially related to AutoCAD program and drawing: "Before starting studies I knew that we were going to work with AutoCAD program, therefore, I was looking forward to learning to this this program" (Stud. 15); "The study subject of Engineering Graphics was of high importance to me because my main goal was to develop my 3D vision and to clarify how to switch from 2D to 3D or from 3D to 2D" (Stud. 16). The majority of expectation were created after the students familiarised with the description of the study subject. During the interview they mentioned some abstract terms: "to learn to use projecting software" (Stud. 18), "I expected to acquire understanding of objects and their position" (Stud. 10). Thus, the majority of students had analysed the future topics, tasks, which they would have to perform in future, had searched in the university intranet, where the descriptions of study subjects were available before they started studying the study subject. Since the study subject is taught to the first year students, their understanding is weak and very few of them study similar study subjects at school. The students are provided with a complex goal of the study subject, which is written by an engineer professional. It is

Table 1. The categories characterising the factors of successful learning of Engineering Graphics among students in Social Sciences.

Categories	What are factors of successful learning of Engineering Graphics for students in Social Sciences?	The focus of research The question that has to be raised by the teacher to himself/herself	Conclusions made for improvement of the study subject
External motives			
Description of study subject	Preparation of an understandable and constructive goal, learning outcomes and other components in the description of the study subject	In what way should the study subject description be presented in writing not to evoke negative reactions in advance?	Preparation of constructive description of study subject
Specifics of study subject	More time allocated to learning and understanding of themes/tasks, which develop students' inner abilities	What features differentiate this study subject from other study subjects of Semester 1?	Balancing the number of tasks with contact hours and independent work
Practical application of knowledge	To start with AutoCAD program and pencil drawing	What topics can increase students' interest and engage them into the study process?	Inclusion and motivation using useful knowledge and assignments that can be applied in the future
The most complex topics of study subject	Concentration and allocation of more time	What topics of the study subject are the most complex ones and what are its reasons?	Raising interest in creative and collaboration tasks
Internal motives			
Learning to learn	The level of students' learning to learn	How does the process of student learning occur?	Development of students learning to learn
Didactic abilities of teacher	The teacher ability to prepare the learning material of different forms and ability to explain it	What influence do teacher's didactic abilities have on students' learning outcomes?	Improvement of teachers' didactic competences responding to learning tendencies of of students Z

difficult to understand it in the beginning of studies. Almost half of the students in the survey mentioned that they had expected their studies of the study subject to be difficult and their has fear. The title of the study subject also contributed to creating an image of a complex study subject: "I had some ideas that the studies were going to be very difficult but I succeeded." (Stud. 4), "I was very scared ….and the title of the study subject sounded as difficult" (Stud. 8); "I expected to draw everything by hand" (Stud. 6). Even such considerations were collected: "… it is interesting, why this study subject has been included into the study programme" (Stud. 7). For this reason, the teacher of the study subject should understand that the majority of students form their primary opinion about the subject after they read the description of study subject. It is necessary to allocate specific attention to its creation and verbal expression. Undoubtedly, the use of speciality-specific terms is necessary but ways how to explain and present fro a new learner of the study subject can also be done.

The Specifics of Study Subject. The students of Transport Engineering Economics and Logistics indicated two main aspects, which make the study subject of Engineering Graphics different from other study subjects in the same semester: development of internal students' abilities and time costs. They can help to identify the factors of successful learning of Engineering Graphics among students of social sciences.

More than half of the students indicated that the most important distinctive feature of this study subject is that their imagination was developed most while learning Engineering Graphics. For example, they stated that: "It develops imagination and you need to think more compared to other lectures. This is an interesting study subject and its worth trying it" (Stud. 16); "This study subject was rather complicated and required visual thinking and understanding" (Stud. 8). The students see the links between the pencil drawing and the AutoCAD program. The majority of them state that combining the work by hand and on computer develop not only their imagination but also engineering abilities: "Both require to develop imagination and help to better imagine all the projections" (Stud. 20). However, the opinion of students about the more useful activity for enhancement of imagination split into two halves: some praised that it is the computer programme. They stated that "Having drawn with AutoCADu, it is much easier to understand how to draw with a pencil" (Stud. 2); "When while drawing with a pencil, it is difficult to imagine invisible lines, you can draw them with AutoCAD and then you see them" (Stud. 5). Such an opinion can be explained by the fact that students are more used to working on computer than drawing by hand. Other stated that that drawing by hand better strengthen imagination. For example, the informants stated that "the very seeing of an object and the imagining of a detail are getting stronger. When you draw with a pencil, then it is easier to draw this object with AutoCAD" (Stud. 3). The computer program shows the object in the space at once, whereas when you draw yourself, you have imagine it. It should be pointed out that half of the students also emphasised the importance of drawing geometry, even though they considered its topics to be the most complex. Thus, all the three parts of topics of the study subject (drawing, computer program AutoCAD, drawing geometry) are important developing the spatial imagination: "All these parts require considerable attention and concentration, ability to see and imagine" (Stud. 10). In this way, the study subject of Engineering Graphics requires seeking the second and the third level of Bloom's taxonomy, i.e. understanding and applying. Development of visual thinking helps to understand a drawing or to draw to complete a task: "This is a study subject, which cannot be learnt by heart, you need to learn and understand it" (Stud. 16); "Engineering Graphics has to be understood and then it will be an easy study subject. And other study subjects you can learn as much as possible but there will appear complex problems like in mathematics, for example" (Stud. 20). it should be emphasised that a number of students noticed development of internal abilities while learning the study subject of Engineering Graphics. They pointed out that namely during the studies of this study subject they developed their certain abilities: "This study subject requires diligence" (Stud. 1, Stud. 21); "creativity" (Stud. 6); "require concentration, diligence and accuracy" (Stud. 5, Stud. 21); "We learn accuracy, minuteness is also necessary (axes, centres, etc.)" (Stud. 22).

Some students stated that they had to allocate more time to Engineering Graphics than learning other study subjects: "This is an absolutely new and not tested study subject, which required more time than any other study subjects" (Stud. 3.). The students also noticed that they had to work during lectures as well: "we learnt a lot of things during the lecture not at home" (Stud. 2), and after the lectures at home: "More independent tasks compared to other study subjects. That is why this study subject is more than others" (Stud. 15.). The ability to plan out and organize lectures does not only help the teacher deliver all the material prepared for the course but also do this in a highly efficient manner, i.e., using in advance prepared tools, structuring the learning material, setting a comfortable pace for the lectures with all the breaks in-between [3]. Thus, planning the package of assignments, the lecturer has to think over the number of tasks and to arrange them within contact and independent work hours not only observing not only ECTS requirements and allocation of hours in credits but also following the principles of consistency and complexity, i.e. from known to unknown gradually increasing their complexity or combining more difficult tasks with easier ones.

Practical Application of Knowledge. The third distinguished category show that it is important for students to see the real benefit while learning, i.e. the practical use of study subject. According to M. Sontag [14], students in the 21st century, who she refers to as the "connected" generation, are particularly interested in the links between what they are taught and the application of learnt material, skill or concept in the real world situations. One fourth of the students stated that there were practical assignments in the content of study subject: "There is difference in the number of practical classes" (Stud. 18); "I acquired practical knowledge as well and this was not just "dry" theory" (Stud 10). It is interesting that students make a distinction between the practical work done on computer in a usual to them way and emphasise the work, when they write or draw by hand: "The nature of work, i.e. a lot of work with paper" (Stud. 7); "a lot of works both on paper and on the computer" (Stud. 14). Z students are not accustomed to writing/drawing by hand during the lectures and completing independent works any more.

Almost all the students emphasised that drawing with the program AutoCAD was the most engaging and motivating activity because to learn to use this program is a high achievement because this knowledge can be used in the future. For example the students stated that: "The most interesting tasks were the ones on AutoCAD because we will be able to use this knowledge later. I like to arrange everything logical in the reality. I mostly enjoyed drawing a plot" (Stud. 3). Interesting assignments and their practical application motivated students and encouraged them to get the highest evaluations. Some students emphasised that they got the highest marks because the study subject was interesting to them: "The most interesting task was to draw 3D projections on a vatman sheet, because it developed my vision from 3 positions (front, top and side). It was really interesting to me and this was the reason why I got the highest marks" (Stud. 16).

The tasks of projecting a plot, which was emphasised by more than half of students, can be attributed to the category of practical knowledge, which develops engineering abilities based on creativity and analysis. Thus, according to the Bloom's taxonomy, such tasks belong to the level of analysing and evaluating. The majority of students liked it not only because of interesting topic but also because they were asked to work in groups "To design a plot and to work in a team were the most interesting things because I felt what it means to argue with members of team because of small details." Collaborative learning has gained recognition in engineering education as a very promising method to develop significant work-related competences [2]. Thus, competences of collaboration, communication, problem solving and others were also developed.

The Most Complex Themes of the Study Subject. Although during the interview the majority of students stated that all the parts of topics of Engineering Graphics develop their imagination, referring to the most complicated topics almost all the students emphasised drawing geometry. The highlighted contradiction may show that the students as if perceive the benefit of drawing geometry relating it with other topics. However, they distinguished it as the most complex part of Engineering Graphics. Such an attitude of students show that they have never thought of their learning process but the article further presents the students' advice to first year students. The recommendations clearly present the level of learning to learn competence. Some students characterised the complexity in an abstract way: "difficult to understand" (Stud. 1, Stud. 2, Stud. 5, Stud. 14, Stud. 15, Stud. 17, Stud. 18, Stud. 19, Stud. 23). One of them explained: "… it costs a lot of nerves to learn it" (Stud 19). The second reason for seeing drawing geometry as complex is related to formulation and content of tasks: "I did not like tasks. It was difficult to imagine dots and lines in the space" (Stud. 3); "My interest in drawing geometry was not evoked because to put 3D images on the coordinate system is not important to me as a student in transport logistics" (Stud. 11); "I did not get interested in tasks of Drawing Geometry. I did not like their conception and formulations" (Stud. 21).

The opinion of students can be regarded and ii is possible to suggest correcting tasks of drawing geometry but a number of students provided clear answers, why studying this subject was complicated. Completing assignments the students had to allocate more time and concentration, they lacked abilities, which can be developed only completing the presented tasks: "Perhaps my visual thinking is not sufficiently developed and for this reason it was difficult to complete assignments" (Stud. 7); "I did not get interested in mini tasks of Drawing Geometry, I was not interested in completing them. I faced difficulties while competing them and they took me a lot of time. But I am glad to have finished them" (Stud. 16). Students experience rejection rather than striving for penetrating into the essence of tasks and their proper completion. Students frequently reflect an action, which requires a lot of efforts and evaluate it as a complex, confusing and uninteresting task and only due to the teacher's didactic abilities and personal qualities (patience, understanding, etc.), the students force themselves to complete these tasks and, thus, to develop their competences. The climate of tolerance in a given class may also have impact on the extent to which students develop professional competences as a result of attending that class [2]. Thus, more interesting tasks should be though of in drawing geometry or could be integrated into other easier topics as well as to explain the practical value of them. It should be also explained what the benefit of every task to a prospective specialist in Transport Engineering Economics and Logistics is. Motives have to be found how to encourage students to dedicate more time and to concentrate for longer completion of tasks, to develop kinaesthetics and spatial thinking. The category presented below is also related to all that.

Learning to Learn. Learning to learn includes the following essential aspects: organisation of the process of own learning; its management, control and evaluation of learning activity and self-control and self-assessment that are grounded on knowledge, skills, abilities and implemented on the basis of positive attitudes. Developing the definition of this concept, it can be stated that the learning competence, i.e. learning to learn, refers to ability and preparedness to independently set learning goals and to plan relevant steps in learning, to discover information for learning independently or together other learners, to solve emerging problems and to self-critically reflect on the process of learning [9]. Thus, during the interview the students were asked to provide recommendations to others based on their experience how to learn. Such a question forced them to think about about the learning process. After the analysis of the received data, this category became the essential axis of the research, which discloses the internal motives of learning success. The question revealed an in-depth attitude of students towards the factors of successful learning of Engineering Graphics, closely linking them with the competence of learning to learn. Firstly, the majority of students, giving advice to the students, who will learn Engineering Graphics after them, recommended following the formal requirements for the study subject, that is, timely completion of tasks assigned by the teacher instead of leaving them for the end of semester: "I would recommend doing tasks on time, then there will be less stress" (Stud. 15); "I would suggest consistently completing assignments and not leaving them for the last days" (Stud. 1, Stud. 6, Stud. 7, Stud. 13, Stud. 23). Another consideration of formal requirement refers to attending lectures. Its importance for the intended outcomes were emphasised by 6 students: "You should not miss classes, make attempts to understand the basics and ask the teacher if something is not clear" (Stud. 18). However, it can be stated that the success is predetermined not by being in the lecture but by active work in the classroom: "we learn a lot during the class…" (Stud. 2). This attitude is confirmed by S. Freeman and others (2014): "To test the hypothesis that lecturing maximizes learning and course performance, we metaanalyzed 225 studies that reported data on examination scores or failure rates when comparing student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses under traditional lecturing versus active learning. Results indicate that average examination scores improved by about 6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning".

Ability to plan time and to perform tasks on time is closely linked with the ability to learn independently. Almost half of the students in the research think that, firstly, the most important think is to contribute significantly to their own learning ("To be as interested and as engaged as possible" (Stud. 2, Stud. 4, Stud. 7, Stud. 12) and to invest more effort performing independent tasks, for example: "Start learning from the first days and make every effort to understand AutoCAD, then drawing with pencil finally becomes interesting" (Stud. 11); "The method that I use for learning – music in my earphones and concentration in the evening. You need calm nerves, when you fail to draw, to concentrate and complete an assignment" (Stud. 21); "You need to spend more time at home working on AutoCAD" (Stud. 17); "To draw one drawing several times" (Stud. 3). Secondly, learning independently, a student has to use additional tools presented by the teacher. One of them, which was mentioned by a quarter of students, are video lessons available in the virtual learning environment Moodle. According to A. Y. Scales [13], originally designed for face-to-face instruction, active learning now must be taken into the newer realm of on-line and technology enhanced learning. The use of active learning is not limited to any specific instructional environment. The students stated that: "You have to watch video lessons, make attempts to imagine everything and, if it is necessary, to draw -this is what I did" (Stud. 3); "… it is also possible to learn to work with the AutoCAD independently because the teacher put excellent lessons on the platform" (Stud. 15). The students also recommended reading a lot of additional literature, analysing theoretical material, which is available in the virtual learning environment Moodle, e.g.: "To read a lot of material, especially, what is provided by the teacher. This information shows consistently how everything should be done and does not allow loosing the track" (Stud. 16); "To read an electronic book, these things helped me" (Stud. 13).

The Teacher's Didactic Abilities. Analysing the competence of learning to learn, it can already be noticed that the teacher's ability to provide support to students, to motivate them, i.e. the teacher's didactic abilities, are related this competence. According to G. Droessiger et al. [3], students link factors for increased motivation to attend theory classes with three main teacher competences: the didactic, the communicative and the personal ones. It is also important to state that students weigh these competences rather unevenly. Although students expect a state of parity between students and teachers and appreciate informal casual interaction, it is obvious that didactic competence has the biggest influence. Almost half of the students emphasised the teacher's ability to explain: "The explanation of the teacher helped a lot because solving of problems was very useful. It helped me to understand Engineering Graphics easier than I had expected" (Stud. 20); "The teacher used to show in front of the class what was not clear" (Stud. 8); "Explanations are clear and my opinion is good, the teacher showed example to the whole group" (Stud. 9). The ability of the teacher to explain and the applied study methods helped a lot to understand the functioning of the AutoCAD program, problems of drawing geometry: "I liked the reaching methods of the lecturer and they were useful" (Stud. 13). Learning approaches are influenced by the teaching and learning environment, and strong teaching has impact on the quality of learning for students (Scales, Varnado, 2012).

The didactic support of teacher is important to one fourth of students, especially, when they have questions or encounter difficulties while completing practical tasks: “The teacher helped many times, when I had questions” (Stud. 20); “…when you fail to understand something, the teacher can always explain it to you individually” (Stud. 23). This can be related to the teacher’s personality as well. Personal competence, which combines various personal qualities (including creativity) and values, is seen as the most essential one (68.6%) in the educational process. During the research the respondents presented the following personal qualities that are important to a teacher: “empathic”, “sincere and able to communicate with students in a simple manner”, “open”, “spreading positive energy”, which show the importance of emotional competence [8]. Several students (3) provided positive evaluation of the teacher’s subject-specific competence. According to Long et al. [6], a good lecturer is characterised by three dimensions: competence, caring and character. Competence refers to how a knowledgeable source is understood, caring means the extent to which a source expresses concern about another person’s well-being, and character refers to how honest and trustworthy he or she is.

Considering the teacher’s didactic competences, a big number of students provided positive evaluation of the teacher’s ability to prepare additional learning material of their study subject and particularly emphasized educational videos: “I have a good opinion about them and in the beginning for a first year student it is difficult to figure out what’s going on. Therefore, the videos prepared by the teacher saved me” (Stud. 11); “I liked video lessons – they were slightly too long but quite simple, clear and, what is most important, useful” (Stud. 21). The presented examples of quotes are in clear line with the learning tendencies of generation Z – short period of learning, high importance of computer technologies and variety of learning material. Several students (3) also provided positive evaluation of teacher’s subject-specific competence. “Have we identified those processes and activities we want to improve and looked at how technology can facilitate those actions? With the introduction of new technologies, we should be looking not at the technology first but at our instructional goals and then the technology best suited to achieve that goal should be selected. Employing a technology because it is the “latest” innovation should not be the impetus for its selection” [13]. According to A. F. Cabrera and etc. [2], an instructor who interacts with students, guides learning rather than lecturing, and gives detail and specific feedback and encouragement provides students with an important model for appropriate and positive collaborative behaviour. Those instructors who introduce clarity and organization to the classroom also have positively influence on the student development. Explaining tasks and activities, clearly defining course expectations, and adopting assignments to the content of the lecture not only increase the ability of students to solve problems but also strengthen their awareness of what an occupation in engineering is all about.

4 Conclusions

It can be concluded that the preparation of the study subject description with the understandable and constructive goal, the learning outcomes and other components is the foremost priority when teaching Engineering Graphics to students of Social Sciences. Furthermore, it is vital to understand that the subject is considerably content-rich and students will have to spend more time studying and carrying out their assignments. Therefore, establishing a reasonable balance between the assignments assigned during the contact hours and the ones for self-studying is of utmost importance. According to the students, the study process should begin with the use of AutoCAD applications and pencil sketching as these methods best facilitate the learning material. Students in Social Sciences found learning via AutoCAD software, blueprinting with pencils and plot design to be the most engaging activities while studying Engineering Graphics. Such choice is explained by the apparent pragmatic utility the students were able to identify in these practices. A susceptibility to the creative assignments done while designing a plot has also been observed. It can be stated that the teaching of students in Social Sciences could benefit from more creative and problem-based assignments, utilizing AutoCAD, pencil sketching and geometry theory. Finalising the analysis of the obtained research data, it is necessary to emphasise that the level of students' competence of learning to learn is among the most important factors that predetermine successful learning of Engineering Graphics by students in Social Sciences. It is important to enable a student to independently make decisions, to plan time and develop internal motivation to attain higher results in coping with learning difficulties. The research results also disclosed that the teacher's didactic abilities have a considerable impact on the students' motivation to learn. The teacher, who is able to explain complex things in a simple way, applies various study methods, present the learning material in different forms as well as externally influence the development of students' learning to learn. Thus, external and internal closely interrelated motives are said to be the main determiners of success in learning the study subject of Engineering Graphics.

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Designing Didactic Orders for Written Examinations - A Topic for the Didactic Training of Teaching Staff in the Engineering Sciences

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Abstract. The study deals with the conscious use of the medium "language" in the design of vocational teaching/learning processes in order to make the examination and assessment process of learning outcomes more transparent and appropriate. For this purpose, the study focuses on the use of tasks in written examinations in teaching/learning processes and in particular on the operators used in these. The question will be investigated as to whether the teaching of operator meanings and the actions required with them leads to an improvement in the results of processing and the understanding of tasks among teachers and learners. To answer the question, a quasi-experimental intervention study in pretest posttest design with one experimental and control group (n = 42) was carried out. Finally, conclusions are derived for the development of a mutual understanding of the tasks among teachers and learners as well as for the pedagogical-practical activity in engineering sciences.

Keywords: Academic-pedagogical special language · Didactic order · Engineering education

1 Introduction

The academic qualification of engineers as specialists for the labour market is one of the core tasks of universities. The changing and increasingly complex requirements of the working world have a significant impact on the methodic-didactic design of engineering teaching/learning processes.

Against this background, an influence on the language use of teachers and learners, which plays a key role in teaching/learning processes [15, 18], can also be assumed, especially since understanding the language of the teacher is of fundamental importance for the learning process and thus for the acquisition of competence by learners. Language can thus be seen as a key element or medium of academic teaching that contributes to the provision of qualified engineers for the labour market. On the other hand, the research and data situation on academic-pedagogical special language and its understanding in academic teaching/learning processes in general, and in the higher

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education of engineers in particular, must be described as extremely precarious. This also applies, among other things, to the formulation of didactic orders in examinations.

Therefore the aim of this article is to systematize selected elements of an academic-pedagogical special language. In addition, a central empirical study is summarized to show the effect of instruction on operators as a core element of didactic orders on processing results and task understanding in written examinations. Findings on this investigation can be helpful to enhance further training of academic teaching staff [14] by improving language comprehension in order to make didactic orders in examinations of engineering degree programmes more comprehensible.

2 Theoretical Background

2.1 Academic-Pedagogical Special Language as a Medium for Teaching in Engineering Sciences

The concept of academic-pedagogical special language is necessarily preceded by an understanding of a general concept of language, which is ambiguous and can only be described by language (i.e. meta-language) [29]. Language subsumes such means which modern man has at his disposal for communicating about things. These represent an independent field of action whose units are language actions [19].

The term “special language” is to be distinguished from this general language term as a partial language, since special language is related to the thought elements of a certain subject, which can be found in technical terms [9]. Special language is acquired through socialisation and learning processes in a certain subject, which goes hand in hand with the development of specific structures of thought and communication, which are above all shaped by the methodology as well as by the knowledge and research interests of the respective subject [4]. Thus, there can be not just one, but a multitude of technical languages, which exhibit a varying degree of differentiation depending on the degree of specialization of the subject [4]. There are currently a large number of definitions for the term “technical language”, whereby in the literature currently available the characteristic of specific language use in separate social contexts can be regarded as invariant [4].

Institutionalised teaching/learning processes in the higher education of engineers also show the characteristic of a separate social context. It is undisputed that teaching and learning has always been significantly dependent to language, communication and interaction and thus to interaction through communication and is inconceivable without the use of language [13, 25, 28]. Teachers use language intentionally and purposefully to initiate and regulate learning processes and to receive feedback on what students have learned. Especially the feedback on what has been learnt enables teachers to design teaching/learning processes to meet the needs of specific target groups [11].

This is of major importance for the training of engineers. Especially due to the high cognitive requirements resulting from technology-oriented teaching content, the functionality of academic-pedagogical special language to support the learning process must be assured, among other things by regulating learning actions. In order to clarify this significance, it is useful to outline the functional scope of academic and pedagogical special language, since it encompasses far more functions in the training of engineers than just the communication about teaching content.

According to Wygotski [30], there are already other language functions that are relevant to this article, in addition to the communication function. He describes, among other things, a signifying function of language, by means of which reference is made to objects. Moreover, language has an indicative function, which is used in intellectual operations to form concepts by extracting individual characteristics and can thus be seen as a primary function of language [30]. In addition, reference is also made to a signal function. This signal function is particularly important for the operators of didactic orders, which are focused on in the following, because operators are used to indicate a certain action to be performed. The signal effect of an operator can be regarded as realized if it triggers an appropriate reaction of the learner to solve the task [22]. Another characteristic of language is its intellectual function. This is shown by the fact that language and thinking cannot be separated from each other, but that speaking, thinking processes and the development of intelligence necessarily go hand in hand [22]. The connection between speaking and thinking is also considered in other works on language as an essential element of teaching/learning processes. For example, Galperin [6] and Zimmer [31] describe further language functions through which the process of learning can be initiated, regulated and supervised. In addition to an exchange or communication function, a differentiation can also be made between an ordering, a processing and a recognition function of language [31]. Both the processing and the recognition function serve as essential elements in order to be able to acquire learning content with the help of language, while the ordering function provides the linguistic arrangement for the orientation of this as a necessary condition of recognition [6, 31]. For a deeper understanding of these three language functions, a distinction should be made between a real action and a mental action. The mental action comprises the mental-linguistic depiction of a model of the real external action and the foreseeing of the possibilities for its execution as well as the course and the result of the real action [6]. The ordering function and the processing function of language are closely related. The concepts conceived during this action process are linguistically analysed with the help of the ordering function with regard to their characteristics and relations, put in relation to each other and then compared with reality [6]. While the ordering function has a rather orienting character through the assignment of characteristics to terms and classifications, the processing function comprises the purpose-oriented mental-linguistic increase of the degree of abstraction of existing and new knowledge [6, 31]. The recognition function of language presupposes the two preceding functions. A gain in knowledge, which is worked towards with the ordering and processing function, is only comprehensively possible if the content of an action has been completely developed [6]. For this it is necessary on the one hand to subdivide the action into its individual operations and on the other hand to emphasize the properties of things, which are of central importance for the realization of the mental and the real action, before these are generalized in the context of processing [6, 31].

2.2 Operators as an Element of Didactic Orders in Written Examinations

From the previous considerations, it is clear that an academic-pedagogical special language is of decisive importance for action and thus for the acquisition, structuring and modification of knowledge by learners in engineering teaching/learning processes. A special element of this special language are didactic orders, since they are used by the teacher in the individual didactic functions or phases of the teaching/learning process in different linguistic ways to initiate performance-producing actions [20]. This serves, for example, in written examinations, among other things, to provide feedback on the learning success of the learners for the teacher and the learners themselves.

Against the background described above as well as the existing lack of relevant scientific publications on the term "didactic order", the characterization and definition of this term is the focus of the following.

Segeth [27] emphasizes that in general, orders are mental entities for guiding or regulating human action and behavior by connecting knowledge and action. Their use requires or causes the execution or omission of actions, actions or operations, often using special terms that are associated with a specific ordering character [27]. He cites the terms "instructions", "guidance", "tasks", "orders" and "reminders" as a subset of orders relevant to educational institutions, and points out that a sufficient investigation of the meaning of these terms and types of orders alone requires extensive interdisciplinary research [27]. Furthermore, he points out that a complete order is constituted by the three components "conditions", "operations" and "aim" [27].

When transferring the general concept of order to pedagogy and specifying it as a "didactic order", Malek (1977) also points out that fully formulated didactic orders include all three components mentioned [20]. For the transfer of the concept of "didactic order" to the pedagogical field, this means that a didactic order should provide learners with both the parameters for the action to be carried out (e.g. a concrete situation or the object of action) and the operation necessary for it (e.g. with the help of an operator in tasks) as well as a aim reference [20]. In addition to the formulation of orders and statements, these three components of an order enable the formulation of questions that are relevant for the examination process [20]. This shows that the term "didactic order" should be superordinated on the terms "task" and "question" and that synonymous use should be avoided [10]. In Malek's pedagogical discussion this aspect is examined and the "task" and "question" are identified as only two possible types of didactic orders. As a result of his considerations, he makes a proposal for the systematization of didactic orders (see Table 1).

On the basis of previous considerations, the term "didactic order" can be defined in reference to Köhler [14] as follows:

Didactic orders are linguistic initiatives of teachers with varying degrees of intensity to make the learner carry out an expected or defined action on an object relevant to the acquisition. Didactic orders contain linguistically coded information regarding the expected action in class, which is used in a planned manner within the framework of didactic functions.

Table 1. Classification of didactic orders according to Malek [20].

Types of orders	Components of the order x = available – = not available		
	Condition	Operation	Aim
1. Task	x	x	x
2. Incomplete task	–	x	x
3. Problem	x	–	x
4. Instruction	x	x	–
5. Guidance	–	x	–
6. Question	–	–	x

However, because language has a natural semantic imprecision [22] and because the construction of knowledge dispositions of the communication partners is individual [10], it can lead to comprehension disorders in the communication process due to different types of information encoding and decoding. One consequence of this can be that the learner carries out actions that are unexpected or unsuitable for the teacher's didactic order in an examination situation [22]. To avoid this, the precise formulation of didactic orders is necessary. For this purpose, operators are used to request the learners to perform actions. With an operator a certain action is named and its execution is initiated [22].

For the work with operators in tasks of examinations and their understanding, it can be concluded that the action required by the operator must be known not only by the teacher but also by the learner. For an adequate presentation of the learning success it is also necessary to compare the operator with the context of the task and to derive the individual steps necessary for the action in order to be able to work on the task in a goal-oriented way. For this purpose, it must be clear from the tasks for their workability which action the learner has to perform or which goal is to be achieved by working on a task [11]. This clarity requires that the learner and the teacher have a mutual understanding of the didactic order or the task. For this purpose it is didactically useful if the teacher's conceptual understanding of common words and operators in didactic orders is made accessible to the learners, or if certain meanings are agreed upon which are suitable for carrying out the action.

3 Summary of the Empirical Study

3.1 Research Question, Study Design and Investigation Process

Within the the context of an empirical study, Köhler [14] investigated the question of whether teaching on the meaning of operators and the actions required with them leads to improvement of the results of work in written examinations as well as to a mutual understanding of tasks among teachers and learners.

For this purpose, a quasi-experimental intervention study in a pretest-posttest design with one control group (G_C) and one test group (G_T) ($n = 42$) was conducted.

The experiment involved 2 school classes of the recognized occupation requiring formal training "state-approved educator". To increase the internal and external validity by controlling central situation and time related confounding factors, a parallelisation of both classes was carried out [12]. The parallelization took place at the level of training organization and at the level of instruction.

In the test group, in contrast to the control group between pretest and posttest, an intervention took place in which the handling of operators was discussed and practiced during the lessons. The intervention was carried out by a teacher who was known to the students since the beginning of their education and who has a high level of expertise in designing of examination tasks. In preparation, the teacher received instructions on the contents of the test and the planned procedure. For the development of the treatment it was necessary to include scientific literature on the description of the actions to be performed, which the operators ask for in tasks, and on the meanings of the individual operators.

The research on this was successful in encyclopedias on philosophy and epistemology [3, 7, 21], the German language [24] and especially in the linguistic literature. In relevant publications from the research area of functional-communicative language description, which appeared mainly in the 1970s and 1980s, didactically relevant findings on some operators can be referred to [5, 26]. The inclusion of these research works in the present study was appropriate, since the communicative processes examined in those studies are understood as types of linguistic-communicative action [8] and consequently correspond with the underlying understanding of the operator as a verb requiring action in tasks of written examinations. For this study, the operator "analyze" was explained in terms of its meaning. In addition, a proposal was made for the implementation of the required action in written examinations [14].

Since it is not possible to directly check the understanding of the task in a quasi-experiment, an operationalisation was carried out on the basis of Aebli's theory [1, 2] to develop the research instrument [14].

In order to be able to draw scientifically justified statements after the quasi-experiment, the data collected were evaluated by means of descriptive statistics and, depending on the data level and the sample size, by means of inferential statistical procedures comparing the two points in time (t_0 und t_1) at which the quasi-experiment was conducted (Wilcoxon-Test; McNemar-Test) and between the control and test group (G_C and G_T) (Mann-Whitney-U-Test; Chi-square Four-Field-Test with Continuity Correction; Exact Fisher-Test) [14]. With an error probability of $\alpha < 5\%$ a test result is classified as significant and with an error probability of $\alpha < 1\%$ as high significant [14].

3.2 Summary of the Results

The results of the empirical study conducted by Köhler [14] support the theoretical considerations of this paper. With regard to the results of the task, the operationalization focused on the structure, the systematics and the correctness of the content of the processing results of a task in a written written examination. The indicators formed included the expectations of the teacher (for examples see Table 2).

Table 2. p-values (Mann-Whithney-U-Test; Wilcoxon Test) of the processing results [14].

Indicator	$G_C - G_T$ (t_0)	$G_C - G_T$ (t_1)	G_C $(t_0–t_1)$	G_T $(t_0–t_1)$
	p (Mann-Whitney-U-Test)		*p (Wilcoxon-Test)*	
Structural response components correspond to task definition according to expectation	.942	.000	.367	.000
Structurally logical structure of the response components according to expectation	.750	.001	1.000	.000
Course of action of the answer leads to the result of expectation	.861	.000	.774	.003
Factual and logical structure of the response	.366	.087	.754	.172
Parts of knowledge to be reproduced are contained in the response according to expectation	.260	.042	.140	.031

The findings in Table 2 show that the processing results of the written tasks of the G_T learners in the posttest are statistically significantly improved compared to the pretest. In addition, statistically significant differences were found between the results of the G_C and G_T learners in the posttest with regard to the structure, the systematics and the correctness of the content of these results, whereas such differences cannot be found in the results of the pretest. The following results of the investigation should be highlighted:

- The findings of the experiment show no statistically significant differences between G_C and G_T in the measurement of the first point of time (t_0) at which data were collected.
- Moreover, as expected, there were no statistically significant changes between the two survey points (t_0–t_1) for the control group (G_C).
- The calculations showed statistically significant differences between G_C and G_T for a large number of the items, as expected, when measuring the second point in time (t_1). Only one item was found for which no statistical significance could be determined.
- For the test group (G_T), the findings of the investigation between the two survey dates (t_0–t_1) show statistically significant changes in accordance with expectations, with one exception for all items of the systematics, structure and correctness of the content [14].

With regard to the development of a mutual understanding of tasks, operationalization was carried out across several index levels [14]. A distinction was made between the course of action and the result of applying the operator-specific mental representation to the task to be worked on, on the basis of which a mutual understanding of the task by the teacher and the learner can be tested. According to the theory of Aebli [1, 2], a distinction was made between 3 types of schemes (concept, operation and action scheme). The formed indicators were differentiated with the individual action steps of the operator used in the tasks (for examples see Tables 3 and 4).

Table 3. p-values (Mann-Whithney-U-Test; Wilcoxon Test) of a mutual understanding [14].

Indicator	G_C–G_T (t_0)	G_C–G_T (t_1)	G_C (t_0–t_1)	G_T (t_0–t_1)
	p (Mann-Whitney-U-Test)		*p (Wilcoxon-Test)*	
Correct connection of operator steps				
Analysis criteria and assignment of the dissected content	.615	.000	.316	.000
Structured learning situation characteristics and orderly examination	.540	.000	.692	.000
Orderly investigation and derivation of conclusions	.013	.000	.002	.000
Derivation of conclusions and formulation of investigation result	.043	.001	.001	.000
The overall structure of the processing result corresponds to the taught structure of action	.768	.000	.289	.000
Taught operator-specific action goal was achieved	.752	.000	.688	.001

The findings of the quasi-experiment in Tables 3 and 4 show improved results for the learners of the G_T, especially with regard to the course of action of the application of an operator-specific conceptual scheme and the application result of an operator-specific operational scheme in the posttest. On the one hand, statistically significant differences between the posttest data of the G_C and the G_T were found. On the other hand, the understanding of the written tasks of the students of the G_T in the posttest showed a statistically significant improvement compared to the pretest.

Table 4. p-values (Ch^2-Test; Fisher Test; Mc-Nemar-Test) of a mutual understanding [14].

Indicator	G_C–G_T (t_0)		G_C–G_T (t_1)		G_C (t_0–t_1)	G_T (t_0–t_1)
	P Chi²-Test	*p Fisher Test*	*p Chi²-Test*	*p Fisher Test*	*p Mc-Nemar-Test*	*p Mc-Nemar-Test*
Implementation of the operator steps						
Short summary	.354			.537	.003	.020
Analysis criteria	.381		.019		.125	.002
Content dissection		.041		.152	.125	.109
Investigation	1.000		.000		1.000	.003
Conclusions		.221	.011		.008	.000
Analysis result	constvalue		.066		.016	0.008

The following significant results were determined in the the quasi-experiment:

- The findings of the experiment show statistically significant differences between G_C and G_T in the measurement of the first point of time of the survey (t_0) for only a few items. There are significant differences in the items for the course of action of the application of an operator-specific operation scheme when processing a task. The data evaluation of the test at t_0 for one item shows a statistically significant difference for the course of action of the application of an operator-specific action scheme when processing a task. The findings also show a statistically significant difference for the result of the application of an operator-specific conceptual scheme in case of one item. This also applies to one item for the result of the application of an operator-specific action scheme. Furthermore, no statistical significance is shown in the findings of the first measurement point.
- In contrast, the calculations for measuring the second survey point (t_1) between G_C and G_T show statistically significant differences for a large number of items, in line with expectations. The only exceptions are two items for which no statistical significance could be determined.
- The findings also show statistically significant changes for some items between both survey dates (t_0–t_1) for the control group (G_C), contrary to expectations. This applies to items of the application of an operator-specific operation scheme in the course of processing and items of the application of an operator-specific operation scheme in the course of processing. The tested data for one item also shows a statistically significant difference between the two survey points for the items on the results of the application of an operator-specific conceptual scheme. With regard to the results of the application of an operator-specific action scheme, the findings show statistically significant differences for one item tested. As expected, the calculations for the remaining items do not show any statistically significant changes for the control group between the two survey points.
- For the test group (G_T), the findings of the investigation between the two survey points (t_0–t_1) show statistically significant changes, in line with expectations, for all items of the application run when processing the task of an operator-specific conceptual scheme, action scheme and operation scheme. This also applies to the items of the application result when processing the task for the operator-specific conceptual scheme, action scheme and operation scheme [14].

In summary, the test results show that the teaching of the meaning and the handling of operators of written tasks has a positive effect on the processing of a written task by the learners. With regard to the promotion of a common understanding of tasks, positive changes can be seen in the teaching of the meaning and the handling of operators of written tasks. This is especially the case with regard to the course of action of the application of an operator-specific conceptual scheme and the application result of an operator-specific operation scheme. This is proven by the statistical analysis of inference data. For the other operator-specific schemes of the course of action and the result of the application of the written tasks this cannot be proven to this extent. Thus, on the basis of the available results of the study, the development of a mutual understanding of tasks among teachers and learners can only be assumed [14].

4 Discussion

A systematization of selected elements of an academic-pedagogical special language is presented in this article. Based on this, a central empirical study is summarized in order to show the effect of instruction on operators as a core element of didactic orders on processing results and task understanding in written examinations.

There are several conceivable causes that impair the proof of the development of a mutual understanding of tasks in the context of the quasi-experiment. A randomisation of the samples used for the quasi-experiment was not possible in the context of this study, so that existing natural groups or school classes were involved. The recourse to existing social aggregates for quasi-experimental investigations is usually used [16, 17]. At this point it should be pointed out that a randomisation of the sample is only one possible reason for the lack of evidence of a common understanding of tasks, which can also occur when working with a randomised sample.

Reference should also be made to the involved teacher or instructor. In spite of the instructions given, it is conceivable that the behaviour of this person influenced the course and results of the quasi-experiment.

Furthermore, it should be noted that individual interpretative components in the understanding of the tasks to be worked on by the individual test persons cannot be excluded, although these components of understanding have already been limited by the design of the quasi-experiment and are not the focus of the present empirical study due to its theoretical foundation. In spite of the high degree of generalization of Aebli's theory [1, 2, 23], these parts of the understanding of tasks have to be named as a possible cause for the difference of the results of the work and it is to be noted that their complete control is not possible. The same applies to possible unintended learning effects and further unknown variables that may have occurred during the course of the experiment. Another important point of discussion is the need to carry out replication studies of the experimental design presented here. The scientific benefit of such studies, especially with larger samples, is seen in the extraction of generalisable statements with a greater range or possibly also for individual occupations, occupational groups or fields of work investigated.

5 Conclusion

For the formulation of didactic orders in written examinations as part of a conscious use of the medium "language" in the academic education of engineers, the following consequences for the further education of teaching staff in engineering sciences are derived, taking into account the considerations of the present investigation:

When preparing tasks of examinations, it is recommended to ensure that the expected performance is clearly defined and that ambiguities are avoided in the didactic orders. This requires the analysis and description of the required actions.

From a didactic point of view, the development of a mutual understanding of tasks among teachers and learners is important for the successful processing of didactic orders. The teacher's understanding of the task forms the basis for creating a didactic order in a goal-oriented way. In order to achieve a mutual understanding of tasks among teachers and learners, all those involved need to know not only about didactic order in general, but also about the meaning of operators and the engineer-specific action required with an operator.

Since didactic orders and operators are elements of an academic-pedagogical special language, it is appropriate to address them in the education of engineers. An academic-pedagogical special language enriched by explicated operators promotes the safe use of the terms in teaching/learning processes and contributes to the development of the learners' competence to act.

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Educators Training in the Context of Socio-Economic and Technological Trends of Kazakhstan

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Abstract. The work presents the results of research carried out within the international project "Engineering educators pedagogical training" (hereinafter referred to as ENTER), co-financed by the Erasmus + European Union programme. There are questionnaires developed for research. The purpose of the survey is to identify ways to modernize the training system for engineering educators. 408 people took part in the survey: teachers of universities (63%), colleges and other educational institutions (23%), employees of state enterprises and corporations (5%), commercial/joint-stock enterprises (9%). An analysis of the results of the questionnaire showed that in the preparation of engineering educators in Kazakhstan, forms of organization of education through electronic education platforms are poorly used (8% of the proposed programs in questionnaire organizations), online courses and mixed-type programs (2% of proposed programs in questionnaire organizations). Not enough attention is paid to forms of networking. Based on the analysis of the requirements of the Kazakhstan labor market for engineering educators, the necessary professional competencies for them are determined. Based on the results of the questionnaire, it was concluded that educational programs should be modernized taking into account regional needs, requirements for key competencies of engineering teachers by employers, and assessment of students' career expectations. For this purpose, constant monitoring of popular and promising areas of training, improvement of forms and methods of training is required. Educational programs and forms of upgrading qualifications should be focused on using the professional context in the educational process, forecasting and creating conditions for the professional development of teachers, providing them with the right to choose a methodological service and the possibility of implementing an individual educational route [1].

Keywords: Engineering pedagogy · Engineering education · Engineering activity

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1 Introduction

For modern Kazakhstan, the training of engineering personnel is one of the key factors of the country's competitiveness, its technological, economic independence. Specific goals and objectives in this area are defined in a number of strategic documents and state program. These documents laid the basis for the formation of an integral Kazakhstan model of innovative education for all levels and forms of education. Among the important educational reforms of Kazakhstan are new approaches to the formation of the state educational order for the preparation of specialists, determined by industry associations of employers. The State Program for the Development of Education and Science of the Republic of Kazakhstan for 2020–2025 provides measures to improve the qualifications of teachers in various formats in the framework of educational programs, including the optimal ratio of subject, psychological, pedagogical, social and other competencies necessary for a teacher to realize all types of pedagogical activity. The conditions of pedagogical retraining are being developed (entry requirements, terms, pedagogical specialties, etc.), which will allow to engage in pedagogical activities to people who do not have pedagogical education. Foreign and domestic companies are involved in organizing internships, master classes, trainings, coursework for teachers to study new production technologies. The modernization of higher and postgraduate education is carried out in the context of global and interdisciplinary competencies of the 21st century (volunteering, civic and social responsibility, leadership, communication, research skills, entrepreneurship, etc.). Considerable attention is paid to the professional development of the teacher through a system of methodological activities centralized at the state level [1]. Priorities for this are leading professional activities, forecasting and creating conditions for identifying and meeting the potential needs of teachers in professional development, ensuring the right to choose a methodological service and the possibility of implementing an individual educational route for a teacher [1]. The measures taken in the country to expand the academic and managerial independence of higher education institutions will make it possible to involve employers more widely in the educational process, determine their coordinating role in training personnel, create new structural management systems, and build the potential of long-term competitive advantages [2, 3]. In turn, labor markets are becoming the main evaluators of universities. To ensure their competitive advantages, universities seek to modernize educational activities, integrate intellectual, human, information, financial, investment resources, infrastructure elements and transform them into a "knowledge network" [2].

In this regard, in the framework of the international project ENTER, a multi-level modular system of pedagogical training of engineer-educators based on international network cooperation is being developed. At the same time, educational programs for the training of teachers of an engineering profile will correspond to such principles as student orientation, parity, dynamism, a conscious perspective, continuity, and versatility of methodological consulting [4].

2 Methods of Research

In order to analyze the content, means and forms of training of engineering educators, the principles underlying the development, implementation and achievement of learning outcomes in educational programs, a survey was conducted in different target groups. The total number of respondents is 408 people. Respondents were classified by place of professional activity and length of professional experience. The respondents included university teachers (63%), teachers of colleges and other educational institutions (23%), employees of state enterprises and corporations (5%), and employees of commercial/shareholding enterprises (9%). In terms of professional experience, the composition of respondents was as follows: more than 20 years (9%), from 15 to 20 years (7%), from 10 to 15 years (6%), from 5 to 10 years (10%), to 5 years (68%). The predominant involvement of respondents with up to 5 years of work experience in the survey was determined by the need to find out the main difficulties of young professionals in their professional activity, the lack of competencies. Also, a large share of respondents to educators of educational institutions is justified by the fact that in Kazakhstan the system of training engineering educators, their professional development, as well as additional pedagogical retraining of graduates in engineering and technical specialties is carried out mainly on the basis of universities (65% of all proposed programs). 65% of all proposed programs in surveyed organizations. Other forms of training of engineering educators are used less frequently and include e-learning platforms and online courses (10% of the proposed programs in the surveyed organizations), on the basis of external organizations and in the form of professional practices at work (25% of the programs offered in questioned organizations). Respondents were asked to provide their assessment of existing engineering educator education programs as part of complementary or self-study programs, as well as engineering or technical training programs at different levels with pedagogical education modules included.

3 Research Results

The development of engineering education today is closely linked to the global processes of social development, the digitalization of the economy, and the rapid growth of technology and communications [5, 6]. The process of modernization of engineering education is stimulated by such global phenomena as internationalization, massization, electronization, commercialization, optimization, etc. These factors imply resource mobility, reduction of international barriers in professional interaction [5, 6]. At the same time, the role of engineering pedagogy is also growing [7]. As the experience of different countries shows, engineering and pedagogical education is defined by national education systems and can usually take the following organizational forms: self-study after the engineering or technical education and integrated engineering and pedagogical education in the training programs for engineering or technical specialists. Graduates of engineering and pedagogical training should have, in addition to technical vocational competencies and engineering and pedagogical competencies [8, 9].

An educator -engineer should be ready to independently create a favorable working and educational atmosphere using various engineering and pedagogical models of the educational process; to build partnership and creative relations with students; to use dynamic forms of classes organization and interactive forms of interaction; to motivate and encourage students to professional development and awareness of their own ethical positions; to stimulate their value orientation, to use various information sources, images.

An educator-engineer should know the conditions for effective organization of the educational process and use them in choosing the training method, create tools for assessment and self-assessment of professional engineering competence of students taking into account the differences between them, know the normative and legal documents in the field of education and the corresponding engineering industry, government programs and other strategic documents in the field of public education and industrial policy [6, 7, 10–16].

A special place in the training of engineering educators and their further professional activity is occupied by the problem of readiness for new digital education and application of new methods and digital tools. In the conditions of digital education, the educator's activity will have an external evaluation by the participants of the educational process, and on the other hand - self-evaluation through reflexive practice, analysis of own mistakes, preliminary analysis and forecasting [5].

Networks of communications and interactions, methodological and communicative forms, network interaction with industry (joint projects of universities and enterprises, participation of business representatives in training of engineers), branch associations and other dialogue platforms, allowing to analyze and discuss the results of training, to optimize training methods and strategies, to integrate new achievements in the field of engineering and didactics into their own activities, through the platform.

In order to rank the key competencies of engineering educators, respondents were asked to rate them on a five-point scale (very important - 5 points, important - 4 points, slightly important - 3 points, not important - 2 points, not necessary - 1 point) [11] Based on the results of the key competency assessment, average weighted assessments (AWA) were calculated separately for each target group and common for all respondents. As a result, the following distribution of key competencies of engineering educators was obtained (from the most important to the less important).

– the use of modern educational technologies (AWA = 4.54);
– professional self-development and self-education, professional development, movement towards success (AWA = 4.46);
– knowledge of real technological and production processes (AWA = 4.43);
– application of information and communication technologies (AWA = 4.39);
– application of practice-oriented methods in pedagogical activity (AWA = 4.36);
– knowledge and application of the basic laws of natural - scientific disciplines, methods of mathematical analysis and modeling, theoretical and experimental research (AWA = 4.34);
– knowledge and application of various methods and approaches to solving technological problems, their optimization, modernization (AWA = 4.33);

- professional interaction with enterprises and organizations (by profile) (AWA = 4.33);
- integration of professional experience in the educational process (AWA = 4.28);
- ability to find, transform and transmit professional information (AWA = 4.27);
- the ability to conduct search and information work (AWA = 4.25);
- selection, adaptation and development of interactive learning methods (AWA = 4.24);
- professional communication and interaction with other people, with the objects of the world and its information flows (AWA = 4.22);
- conducting scientific, innovative activities in the field of engineering (AWA = 4.22);
- analysis and interpretation of professional data in the field of engineering and preparation of recommendations for their practical use (AWA = 4.21);
- ability to work in a team (AWA = 4.20);
- conflict management and resolution (AWA = 4.17);
- development and application of project training technology (AWA = 4.16);
- development of educational and methodical documentation, design of training methods (AWA = 4.12);
- the ability to perform various social roles in the group and team (AWA = 4.09);
- knowledge of project management methods (AWA = 3.8).

It is important to note that according to the results of ranking of key competencies, the best correlations were observed in the responses of teachers of various educational institutions. The answers of teachers and representatives of enterprises are weakly correlated with each other (correlation coefficient less than 0.5). This indicates a weak interaction of educational institutions with the economic sector in the formation of educational programs and determining the key competencies of graduates. At the same time, representatives of enterprises from the list of key competences presented above highly rated professional communication and interaction, professional self-development and self-training, the use of information and communication technologies, analytical skills in interpreting professional data, knowledge of real technological and production processes, the ability to work in a team, the development of educational and methodological documentation and the design of training methods.

Thereby, the content of the training and professional development of engineering educators should be based on the idea of "integrating the different branches of knowledge that are part of the teaching profession" [7, 10–13, 17]. Engineering educator training programmes should have clearly defined objectives and good methodological support. The training process should be optimized according to a certain set of indicators (compliance with social development trends, social order of the state, regulatory documents, ideas of modern pedagogical science, professional interests of teachers and students, optimal use of all resources to achieve sustainable positive results, combination of elements of different methods, etc.). Training should be organized using modular, problematic, concentrated, contextual, information and communication, project and other educational technologies [7, 10–13, 18, 19]. Education curricula for engineering educators should include modules on innovative production and teaching technologies, entrepreneurship and commercialization of professional results, on concepts of engineering education for different industries. At the same time, our respondents with up to five years of professional experience note a lack of economic and psychological knowledge, and point to problems related to communication and management skills. When organizing independent work of students, it is important to ensure flexibility of training, its focus on individual characteristics and needs of the individual [5–7, 10–16].

In general, from the results of the questionnaire it follows that the content of educational programs should ensure the achievement of the following learning outcomes [11], arranged in descending order of the average weighted assessment (AWA):

– knowledge of technologies of self-learning, self-development, self-regulation and self-support (AWA = 4.52);
– the ability to classify and combine theoretical and practical knowledge (AWA = 4.39);
– the ability to systematize, analyze approaches to the study of the development of engineering fields (AWA = 4.37);
– demonstration of logical and analytical thinking skills (AWA = 4.32);
– use of modern information and communication technologies (AWA = 4.28);
– planning and conducting scientific and technological experiments to solve complex engineering problems (AWA = 4.26);
– design and operation of production lines, development and modernization of production technological schemes (AWA = 4.25);
– ability to document the results of professional activities (AWA = 4.24);
– application of innovative methods (AWA = 4.22);
– knowledge of educational design technology (AWA = 4.16);
– conducting resource assessments and proposing technological / practical solutions (AWA = 4.14);
– knowledge of the basics of management (AWA = 4.09);
– knowledge of the basics of the organization of pedagogical activities to improve the skills of employees (AWA = 4.06).

In the ranking of learning outcomes, the average correlation coefficient between the responses of university teachers and enterprises was 0.7. The average coefficient of correlation of the responses of teachers of colleges and other educational institutions (except universities) with the answers of representatives of other enterprises is 0.18. Thus, we can conclude that for educational institutions (except universities) it is necessary to modernize educational programs for the training of engineering teachers taking into account the requirements of the economic sector and to update the learning outcomes based on monitoring the labor market and modern development trends.

Special attention should be paid to the issues of professional development of engineering educators. The choice of forms of training organization in the professional development system is a complex and largely contradictory process. It generates new pedagogical technologies, changes the idea of inter-subject relations, modifies the previous scientific and methodological support, and determines the variability of programs and training courses. To date, the most common forms of professional development of engineering educators in Kazakhstan are programs organized on their own base, which is confirmed by 41% of respondents participating in the survey. According to 24% of respondents, it is possible to implement professional development programs for engineering educators on the basis of third-party organizations of the related profile or on the basis of the departments of professional development of universities. Much less frequently such forms of professional development are used, as the organization of training through platforms of electronic education, online courses, in the form of industrial practice, programs of mixed type, which account for about 10%. This situation clearly requires the expansion of the role of electronic, digital and Internet learning in the training and retraining of engineering educators, which will make it possible to effectively transfer innovative experience, conduct innovative experiments, provide high-quality educational services tailored to the individual needs of the student, expand opportunities for students, develop their leadership skills, personalize training and provide effective feedback [5]. This issue has received considerable attention in recent years at ICL (International Conference on Interactive Collaborative Learning) conferences [5].

4 Conclusions

The transition to a digital economy, the international division of labour, the intensive exchange of information are now placing greater demands on the quality of engineering education, making fundamental changes in the professional training of engineering educators, and enabling the use of new tools and forms of teaching [5, 14–16]. The development of the system of retraining and professional development of engineering educators presupposes a new methodology for defining and coordinating the goals of educational, research and production activities, orientation to a high level of personal potential development, development of abilities to integrate, generate ideas from various fields of science, industries, operate interdisciplinary categories, use professional context in the learning process. Modernization of educational programs should go through the identification and strengthening of relevant and promising areas of training, development and improvement of forms and methods of training, evaluation of learning outcomes, professional skills and competencies of students, creating conditions for the development of competencies and skills of educators and staff involved in the educational process.

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Professional Skills for Developing Supportive Learning Environments

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Abstract. This research on the topic of STEM teachers' professional skills for structuring and developing supportive learning environments in order to implement National Curricula (NC) in schools, vocational schools and study programs at student hobby centres is a pilot study based on the need to use existing resources more rationally to advance students' achievement. The research question posed in this study was 'What is STEM teachers' understanding of supportive learning environments in schools and hobby centres and opportunities for their design and development?' The data collected and analysed (n = 31) in 2020 enable us to examine the development of teachers' professional abilities and creativity at structuring and designing supportive environments for learning STEM (Science, Technology, Engineering, Math) subjects. Intelligently designed and constructed environments specific to the subject support and promote learning, lead to higher academic achievement, and contribute to students' self-esteem. The pilot study also provides information about teachers' professional approaches, actual school environments and areas for improvement. The analysis of the data is accompanied by recommendations for teacher training in the design of environments appropriate to different types of educational institutions. The current turbulent times require increasingly broad competencies and creativity on the part of teachers for making STEM education socially meaningful, and the implementation of curricula and study programs more cost-effective.

Keywords: Supportive Learning Environments (SLE) · Structured course-specific environments · Professional skills for developing learning environments · Cost-effective implementation of curricula

1 Introduction

That is what learning is. You suddenly understand something you have understood all your life, but in a new way – Doris Lessing.

Learning and new knowledge usually lead to a better understanding of one's environment, which also means the ability to alter one's behaviour and/or adapt to

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changing conditions. This is precisely the situation we are facing in 2020. One needs to be able to comprehend new realities and limitations, and to consider opportunities to adjust to them. Learning happens in different environments, and the history of pedagogy can offer interesting insights into how these have developed – from walks with Socrates to printed books and the establishment of schools as institutions to today's web-based learning environments. New fields of education such as school architecture, the development of curricula and study aids, and educational psychology and sociology have each made a unique contribution to the enrichment of supportive learning environments. Finally, there is the economics of education, which more often than not has had the final say in educational policy making, deciding what countries or societies can or cannot afford to spend on the education of their people.

Developing supportive learning environments (SLE) has inspired educational reforms everywhere in the world. The specification of mandatory minimum SLE is usually related to the implementation of new national curricula (NC) in different types of educational institutions, primarily for compulsory education. The issue of learning STEM subjects has been a widely debated topic in all countries since the Western world experienced 'Sputnik shock' in 1957, and in Estonia, where school curriculum development has been a difficult and often controversial process since statehood was regained in 1991. Educational objectives, and the selection and organisation of learning content is usually specific to each country and culture, and as the world around us is changing rapidly, the lifespan of these 'plans for learning', as Hilda Taba has defined NC, usually does not exceed a decade. Understandably, traditional plans and programs for learning a particular course in music or elementary maths can survive somewhat longer, but it is an accepted fact that changing demands for education mean that some new school subjects will appear and others will disappear. This happens according to what is considered necessary and meaningful to know and to be able to do in order to prepare a new generation for future life, in answer to the perennial question 'What is worth learning'?

2 STEM Education and Environments

Estonian NC for schools have always contained many different compulsory school subjects representing particular fields of human knowledge and experience. There are languages, music, social studies and STEM subjects, which are usually specified as maths, physics, chemistry and biology. The question has often been asked whether the number of subjects has to be so great, but it has been the tradition in Estonia to take a so-called encyclopaedic approach to selecting the content of learning. The inclusion value of the subjects in NC has never been questioned, and in recent times some new subjects (e.g., career education and foundations of economics) have emerged. Moreover, different lines of study and specialised classes that provide opportunities for in-depth learning in almost all subjects have been available in Estonian schools since the 1960s. Understandably, STEM subjects are of particular interest today and are especially necessary for those who aspire to becoming an engineer, a chemist, or a specialist in a field of medicine, to name just a few.

All of these worthy cultural and social aspirations and objectives, carefully selected content and expected learning outcomes have to be put into practice at the level of the school. This means that the relevant conditions have to be created for acquiring particular knowledge and skills. Teachers require the professional skills to implement NC through specific learning activities in suitable and supportive learning environments. It bears repeating that all school subjects require a distinctive environment.

Our research was triggered by the fact that studies in creating SLE for school music education have been carried out at the Estonian Academy of Music and Theatre since 2013. These have shown that music teachers as well as teachers of other subjects have to consider diverse opportunities for creating subject-specific SLEs and must have the skills to structure and develop them into practically functioning systems. (Laanemets and Rostovtseva 2015; Kiilu et al. 2020).

This article is a report of a pilot study carried out by the IGIP Centre at Tallinn University of Technology that provided preliminary results describing the professional skills, opinions and understanding of SLE on the part of teachers who participated in in-service training courses in 2020. For Tallinn University of Technology, STEM teachers and the results of their work in different institutions are of particular significance, as they prepare students for university-level education. The entry level of these candidates has a considerable impact on the higher technical education they have chosen to pursue. The students are also expected to have the interest and motivation to experiment and not be afraid of making mistakes, as analyses of errors are useful for learning and developing creativity.

3 Background

Learning environments have been a topic of interest for a considerable time. Lewin (1936) was likely among the first to discuss the concept of person-environment fit (PEF), and he believed that by creating learning environments that align with the needs of learners, educators can maximise their students' and their own achievement. Edmonds (1999) asserted that all learning environments are complex and multidimensional. It is not always easy to specify and structure all the components of SLE that are needed for a particular course or topic of study. Even if the components are known, e.g., for STEM subject laboratory work in particular, it is still complicated to combine them into a meaningful system, provide suitable SLE for acquiring specific knowledge or skill, or construct a working model of a particular mechanism.

Understandably, as learners vary at different times, teachers must also be able to create diverse learning environments. The decisive factor for commencing learning at any stage of education is the initial level of the students. That is why the World Education Forum 2020 identified early childhood education as a priority and the first and most important stage of lifelong learning. The proverb 'Well begun is half done' is still valid, and it is necessary to prepare for a smooth transition from one level of education to the next, which means that expected attainment targets have to be set as prerequisites for further studies. STEM education must begin as early as possible.

Teachers must thoroughly master their subject so that they can recognise a diversity of possible opportunities to understand the meaning of the knowledge and skills it provides. Twenty-first-century educators have agreed that the learner is at the heart of creating SLE, and that students as well as teachers should understand why a particular learning environment (technical, cultural, linguistic, etc.) is useful. It is also important for teachers to identify meaningful features of SLE in order to create developmentally appropriate conditions for learning. These should correspond to the cognitive and other skills in the learners' zone of proximal development (Vygotsky). Elements of SLE such as security and comfort are also important as they can be expected to improve students' motivation.

From the perspective of educational economics, ideal SLE are unattainable for two reasons: inadequate resources and the rapid appearance of new study aids and environments, especially virtual environments. With regard to the cost-effectiveness of educational reforms Wilson (1995) has described minimal learning environments in which there are learners and functional study spaces. Several scholars have considered the whole world to be potentially usable for learning, and Salomon (2006, 255), for example, considered any environment suitable for learning, if designed for that purpose. For him, learning as a supervised process and instruction provided by competent teachers by means of computers, worksheets, etc. are the essential components. Harsh and Young (2015) provided real-world examples that are conducive to deeper learning for achieving optimal academic results. They claim that variations in the environment can be designed to enhance the content, augment instructional processes and expand the range of students' educational outputs. (Harsh and Young 2015, 79).

Attempts have been made by several researchers to analyse and structure environments in diverse ways, but it is difficult to generalise or even describe them adequately, as the courses to be taught and subjects to be learnt are so different. Finnish specialists (Manninen et al. 2007, 36–41) identify different fields – physical, social, technological, local, didactical – and provide an overview of opportunities that each offers for learning, taking into account the potential of each as an SLE for a particular activity. In Estonian teachers' training, when discussing supportive learning environments, we specify a minimum of three major fields: spatial conditions (including school architecture), study aids (traditional and modern) and social environments. (Läänemets 2017, 46–47). Spatial environments, starting from school buildings, must be functional and provide the facilities required for specific learning activities, e.g., classrooms, libraries, computer classes, gyms and labs. Under the present conditions, all infrastructure including school grounds, school transport and study aids must meet safety, hygiene and aesthetic standards as never before.

Different kinds of study aids need to be designed for the acquisition of the learning content specified in the NC syllabi to produce the expected learning outcomes. Traditional textbooks, workbooks, maps, instruments, etc. are still used, but there are other and more numerous study aids available in virtual environments. The recent experience of school lockdowns has proved that both are needed, as learners have diverse study skills and home environments, especially in terms of the availability of computers and individual learning spaces.

There is ample research pertaining to different web-based and traditional learning environments. The learning potential of textbooks has a long history in different countries. The research of Finnish educators deserves particular attention. Ruuska (2015) considers a textbook to be a framework for learning (Ruuska 2015, 43). Vuorinen (2015) describes all teaching materials as tools designed for teachers and pupils, the main function of which is to enable access to new information and learning

(Vuorinen 2015, 117). Elomaa (2009) suggests that teachers like to use textbooks because they do not have the time to prepare appropriate material themselves (Elomaa 2009, 31). As textbook authors usually follow the NC syllabi, these are also a reliable guide for teachers and if they wish, considering their students' potential and interests, they may add materials (additional texts, training materials, etc.) they consider appropriate. Guerretaz & Johnston claim that the textbook provides an ideal structure for organising learning and can even serve as a curriculum (Guerrettaz and Johnston 2013, 781). In many countries it is true that teachers prefer to select a textbook suitable for themselves and hopefully for their students, and use it for a long time, if there is no change in the NC or educational reform.

Social environments are usually specific to cultures and school traditions. Schools can be managed and learning activities organised in diverse ways. The issue of centralised or decentralised management is usually stipulated by educational legislation. All schools aspire to rational timetables and professional teamwork, a friendly and supportive atmosphere, safety and mutual respect. This includes cooperation between school and home, and later on employers as well, and meaningful integration of all opportunities for formal, informal and non-formal education (Läänemets et al. 2018).

Although some general principles for developing SLE can be specified, their design is germane to each subject and greatly depends on the teacher's professional skills and creativity. It can be concluded that the development of SLE for STEM subjects deserves particular attention, as there is a clear need to improve students' achievement (see PISA results, etc.) in these fields.

4 Data Collection and Respondents

The basic research question sought to determine how teachers understand the concept of learning environments and how they can be structured. In order to describe their analytical professional skills the following questions were posed:

1. What kind of physical and social environments for STEM subjects can teachers currently use for organising the learning process?
2. What are the materials/study aids they can use to develop supportive environments?
3. What are teachers' current needs for creating supportive learning environments for stimulating and successful STEM education?

The research data were collected by means of semi-structured web-based questionnaires from January to March 2020. The questions were somewhat influenced by the theoretical framework, but the analysis was principally data-driven (Vanha 2017, 25). The data were analysed using the content analysis method (Tuomi and Sarajärvi 2009), which describes the phenomenon – in this case learning environments for STEM education – and aims to create a clear verbal account through text analysis. The purpose of analysing qualitative data is to increase the value of the information in order to produce meaning, clarity and coherence from disparate data. (Vanha 2017, 24).

The questionnaire (26 questions) was sent to 142 students at the IGIP Centre of Tallinn Technical University who were receiving training as a STEM teacher. We received 31 answers (22%). Sixteen of the respondents had MA degrees, one had a

PhD, nine had a BA and five had diplomas in applied higher education. 42% of respondents had acquired their pedagogical education during their pre-service studies, and 58% were currently studying to acquire an additional qualification. 42% had 1–5 years' work experience as teachers, 26% had 6–10 years, and 10% had 11–15 years. 16% of respondents had 16–20 years and 6% had taught for more than 20 years. 29% reported their weekly workload to be 20–30 lessons/contact hours. There were three equal groups of respondents (each 19%) with a weekly workload of less than 15, 15–20 or 30–40 lessons/contact hours. 13% of respondents reported an almost unbelievable workload of more than 40 lessons/contact hours per week. Many STEM teachers also work as engineers or specialists in business enterprises. According to data from the Ministry of Education and Research only one third of Estonian teachers work full time at that profession.

5 Results and Discussion

5.1 Physical and Social Learning Environments

87% of teachers deliver their lessons in classrooms, and 68% present part of their studies online. 42% of STEM teachers use labs in their schools, 16% of respondents use labs at neighbouring schools or universities, and 13% use studios or workshops, premises of business enterprises, or open-air environments. 10% of teachers reported organising independent work to be done at home, and 7% use special seminar rooms. In some cases (3%), remote labs, home-based projects, and computer classrooms are used.

When teaching and learning science it is crucial to use laboratories and other environments in addition to traditional classrooms, as practical activities and experiments make up an essential part of the courses. In view of the emergency situation from 12 March to 17 May 2020, the role of e-learning has increased significantly, as numerous virtual learning platforms have been added to traditional environments. In general, practical STEM subjects are rarely taught and learnt online, since in-person contact is needed for learning-by-doing or hands-on learning. Minds-on learning is of course needed to support the development of critical and technical thinking in the acquisition of these subjects, as well as the organisation of relevant learning activities. A few teachers mentioned that some students do not like to study online, and others clearly prefer web-based learning. A constructive balance must therefore be established between different ways of learning and environments without diminishing the quality of the process.

The responses also revealed that teachers have very few opportunities to combine or change the learning environments that they deem necessary or most suitable to fulfilling the aims of the lesson or the learning content. This is most needed for flexibility, attracting interest, for avoiding tedium or becoming bored. STEM subjects presuppose practical activities, and training in particular skills and even observations are more active than passive. Theory and practice are often combined in field trips, independent e-learning and tasks performed in computer classes. It also became evident that STEM teachers tend to use no more than three different environments. Theory lessons often take place in labs where new knowledge can be quickly put into practice, which is highly motivating and interesting for students. As reported, there are more opportunities for teachers to combine different activities and methods than to change environments. They also integrate labs with online environments (e-labs, simulations), or rearrange rooms to make them suitable for group work. Some theory lessons also take place in e-environments (demos), but practical work must be done in labs. The character of the learning tasks and the school timetable form the basis for the design and selection of various physical environments. Smaller rooms are preferred for working in small groups, as they facilitate eye contact. Teachers also mentioned that students did not like long theory lessons; they consider practical work in labs and workshops more interesting and inclusive.

90% of testing takes place in traditional classrooms. Internet/Moodle environments are used by 61% of respondents. This can be explained in part by the recent emergency situation in which organised learning has mainly been web-based. 35% of respondents also conduct tests and other assessment activities in labs, 13% in studios or workshops, and 6% in seminar rooms and computer classes.

The data showed that teachers work with various sizes of groups or classes of students. 39% of the respondents teach groups of 10–15, and 6% have groups of 10 or less; 23% teach classes of 16–20 students, 32% have classes of 21–25, and 29% have classes of 25–30. Larger classes have also been reported: 16% of teachers work with groups of more than 30. 3% of respondents also mentioned classes with a maximum of 45 students. The typical size of a group for learning STEM subjects is 21–30 students.

5.2 Study Aids

55% of respondents said that each student has a textbook provided by the school, and 7% of teachers responded that textbooks have to be shared between two students. However, the availability of textbooks cannot compensate for problems related to learning STEM subjects.

It was reported by more than one third (35%) of the respondents that they personally compile study aids for their students, because there are no suitable modern textbooks for STEM subjects available. Vocational schools use professional specialist materials, sets of examinations, prescribed standards, instructions, legal acts and handbooks (16%). The respondents also use textbooks in English for teaching STEM subjects as there are no up-to-date study aids in Estonian (10%). They also use e-textbooks and digital study aids available on the Internet (10%). The teachers have also tried to get support for using materials published by Tallinn Technical University and textbooks published in Russia.

Teachers assessed the quality of study aids in terms of logical structure, systematic presentation of the content, and simple (not simplified!) explanations (structure of the text, highlighted themes, subtopics, and information to be committed to memory). The principal problem is a lack of modern study aids with high-quality content. The work of teachers in meeting students' needs and interests would be greatly assisted and less time consuming were they able to access such study aids.

30% of the STEM teachers considered workbooks necessary, 16% highly necessary, and 16% did not think they are necessary. 19% of respondents said they would gladly use them if schools would supply them (NB: In Estonia the schools themselves decide which study aids to buy according to their budget).

42% of respondents use workbooks on a regular basis, 26% confirm that all of their students have individual workbooks, and 7% copy a few useful pages from the workbook from time to time. Teachers themselves compile workbooks, worksheets and e-workbooks in order to provide students with examples of practical applications. This is an extremely effective approach, as the teachers have first-hand knowledge of their students and are able to integrate all the necessary components of the course in a way that is meaningful to and suitable for them.

Teachers who are willing and desire to make their lessons/seminars more interesting and varied naturally like to use workbooks; they are also good tools for practicing and reinforcing the knowledge to be acquired. Vocational school and IT teachers find that practical activities are best for consolidating acquired knowledge and skills. They also find that projects related to the profession and skills training are beneficial. Problem solving, designing and reading graphs and diagrams, as well as other practical exercises are particularly important in teaching STEM subjects. They also mentioned that e-workbooks would make the process faster and simpler. Additional practical work guidelines, templates for lab protocols, and bases for data processing would be welcomed. These respondents also thought that traditional workbooks were not particularly helpful, as too many tasks have already been compiled and there is not much that students can do on their own.

58% of respondents thought that there is sufficient IT equipment (computers, software) in their school labs for teaching and learning STEM subjects. 39% of respondents share this opinion with regard to IT subjects. 29% of respondents who teach chemistry, physics and robotics, 16% of biology teachers and 19% of science teachers are satisfied with the availability of lab equipment. However, 26% of respondents report a lack of lab equipment. This might explain why 16% of teachers use labs at neighbouring schools and universities and 13% of teachers conduct lessons at business enterprises.

5.3 What are Teachers' Current Needs for Creating Supportive Learning Environments for Stimulating and Successful STEM Education?

The respondents would like to have access to more equipment, types of technology, and lab assistants when teaching STEM subjects (39%), as well as materials and tools (23%). 13% of teachers mentioned safety conditions in labs, chemicals and hazardous materials. Also cited were a lack of study aids in the native language of the learners, tasks related to real-life problems, simulations and IT support.

The responses to the questionnaire also provided preliminary information about the kind of activities teachers arrange to increase the attractiveness of their subjects for broadening their students' view of the world, and to introduce diverse learning environments. Teachers traditionally prepare their best students for participation in subject olympiads (26%) and various competitions: Robotex (29%), Robomik, First Lego League, Küberpähkel Goldberg Machine, Progetiger, Känguru (Kangaroo). In addition, there are events for different fields of engineering, such as '100 Steps in Engineering', and ETA student research presentations. Teachers and students also participate in science fairs and visit AHAA Science Centres (42%). Lab tours and excursions and trips to business enterprises were mentioned (52%), and some have been to international exhibitions in Estonia and abroad. Tallinn Technical University often provides opportunities for students to use its labs for virtual reality, digi-printing, autonomous self-driving vehicles, and industrial robotics (45%).

All the activities reported by the teachers help to attract attention to STEM subjects, develop interest and motivate students, especially in an environment in which the sciences are not very popular among young people. Consequently, the efforts of STEM teachers have particular social significance, especially with regard to opportunities to create diverse learning environments. Students begin to comprehend the potential applications of the sciences in our everyday lives, and also the value of STEM qualifications in future labour markets. This might encourage more young people to consider entering a STEM field.

6 Conclusions and Recommendations

When creating SLE teachers primarily base their decisions on particular teaching methods (42%). 24% of respondents highlighted the importance of the following factors: room conditions, study aids, size of the class/group, technology, and methods. 13% of respondents accord primary importance to study aids.

The teachers consider information regarding the design, structure and creation of SLE necessary to their profession. They cite the importance of SLE to achieving the expected learning targets (36%). 13% of respondents mentioned opportunities for rationally organising their work, especially in terms of available resources (time, money, competence). 19% of teachers think this type of professional knowledge and skills produce resource savings and make their activities more cost-effective. 32% consider this knowledge an essential part of teachers' professional training.

Approximately 75% of respondents are convinced that their school management supports (48%) or highly supports (26%) STEM education and the development of SLE to assist it. Nevertheless, some teachers are worried about local government decision making with respect to school budgets. Parents exercise considerable influence (52%), and schools can do more to involve them. Information about STEM activities – formal, informal and non-formal – can reach wider audiences through field trips or other extra-curricular activities, in order to garner parents' support (26%).

The question concerning problems STEM teachers are facing elicited the most diverse feedback, as expected. They lack simulations, modern technology, subject literature in Estonian, practical exercises related to everyday life, lab equipment, and lab assistants. They also require support for teaching children with special educational needs (SEN), learning difficulties and behavioural problems (disruptive students). They would like to have better cooperation between teachers and schools, and the formation of professional networks, which are currently weak or non-existent. Some schools lack space for activities as well as essential study aids. The respondents also recommended that more attention be paid to STEM subjects, especially opportunities for their integration. Effective STEM teaching and learning is greatly hampered by teachers' inability to combine the aims and subject syllabi of the national curriculum, the exercises presented in textbooks, national class level and other tests, and exam requirements into a meaningful and integrated whole. The teachers need more in-service training time and resources for developing their professional competencies.

The teachers complained about students' lack of knowledge when they enter STEM classes. This indicates that they have not been given an adequate foundation in earlier grades, especially in maths and reading with comprehension, which are crucial to further studies. Students are not motivated to study STEM subjects, and science professions are unpopular. Recognition of scientific knowledge has decreased, and many people do not acknowledge the necessity of independent and critical thinking skills, which makes higher-level learning of STEM subjects impossible.

The responses to the questionnaire showed appreciation of STEM teachers' work and dedication, but they definitely need assistance and support. There are problems related to study aids, learning environments and in-service training. Too many teachers are forced to compile study aids themselves as there are no suitable textbooks in the students' mother tongue.

There is another aspect of teaching and learning STEM to be considered – the students. Learning these subjects requires self-discipline, effort, interest and a positive environment. It requires learning with comprehension and the expected academic achievement presupposes critical and technical thinking skills. Unfortunately, the development of SLE for STEM subjects has been mainly or wholly the responsibility of teachers. In many cases, modern labs with adequate equipment are unaffordable. Nevertheless, teachers try to compensate for these inadequacies with field trips to universities or other interesting locations. Another problem is the lack of financial support from local authorities, leading to reliance on assistance from parents. STEM teachers have a heavy workload, and they work in different schools, which leaves little time or opportunity for individual study and application. Students are not particularly interested in the subject, and they have little interest or desire to make an effort or focus on their studies. Especially worrying is the devaluation of knowledge and thinking skills among the wider public. Recent experience with web-based learning at home, necessitated by the pandemic, has clearly highlighted the issue of balanced learning environments, as different learners have different learning strategies and techniques as well as different home conditions, especially in terms of the availability of IT.

The results of this pilot study will be used to develop the content of the curriculum for STEM teachers' acquisition of additional pedagogical qualifications. Tallinn Technical University is creating an updated MA curriculum for recruiting STEM specialists to become teachers, which will include a special course in SLE. The data can also be used by other institutions to develop a course in SLE, which forms a meaningful part of any subject's didactics, for teachers' pre-service training. The data, which identify problems related to learning and teaching STEM subjects, will be made available to school authorities and local officials. The intelligent development of SLEs would make learning any school subject in any educational institution more successful, meaningful and cost-effective.

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Poster: Analysis of the Differences in Adaptation to Higher Education of the First-Year Engineering and Humanities Students

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Abstract. The Bologna process gives unlimited opportunities for modern youth to continue their studies in different countries and increases the mobility of students, yet at the same time creates a problem for quick adaptation and mobility of the student environment. The speed and effectiveness of students' adaptation largely determines the success of the learning process. The objective of this research is to define the differences in adaptation processes of first-year students of engineering and of humanities to university education. Our hypothesis is that there exists a difference between adaptation of engineering students and adaptation process of students of humanities because of the difference in original skills and competencies. As this research has shown, the lowest score of general adaptation was observed among the male engineering students. Self-assessment of adaptation level among the engineering students (regardless of the gender) is lower than among the humanities students across all the adaptation scales.

Keywords: Adaptation · Higher education · Students · Academic adaptation

1 Context

Studying in a higher education institution is different from studying in a secondary school on many counts. For example, university education requires of the students a more independent and responsible approach to studying and its results than at school. Quite often transition to higher education for university entrants requires serious revision of their studying strategies and leads to a period of adaptation to the university education process. This adaptation phase becomes longer in case of entry for education to a foreign university. The Bologna Process gives the modern youth unlimited opportunities to continue their education abroad thanks to the academic mobility of students [4, 19]; at the same time, this creates the problem of their adaptation to the new environment [16].

Besides this, there exist several factors which complicate adaptation: the geography of students' movement, cultural differences of each country and region where students end up studying, educational environment, different motivation forms and methods at

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school and in a university, different levels of students' academic independence and age etc. Therefore, it is quite clear that students' adaptation to higher education is a complex process which depends on many factors [10]. The factors of high students' mobility and varying requirements of different universities make the students' adaptation to their university studies a process which deserves an in-depth and comprehensive analysis [5].

Adaptation is a complex process which affects all aspects of a person's life. Researches distinguish several inter-linked aspects. In the opinion of A.A. Rean "The most complex and heterogeneous aspects of the adaptation phenomenon manifest themselves in a versatile human activity where we can single out psycho-physical, behavioral, cognitive and subjectively personal components of the adaptation process" [13]. By approaching adaptation as a multi-faceted and complex process we could distinguish four elements of students' adaptation to university life: physiological adaptation, academic adaptation, social and cultural adaptation, and socio-psychological adaptation [9].

At any given moment of the adaptation period these elements have particular significance and weight, their effect on the process and the result of adaptation. In the opinion of some researchers, the speed and efficiency of students' adaptation determine to a large degree the success of their university education [2]. Therefore, it is critical to take adaptation into account when designing university curricula. This could increase efficiency of the education and reduce the chances of students' dropping out due to poor adaptation to university education. In order to design effective university curricula it is important to understand the dynamics of adaptation processes of students from different study programs.

2 Goal

The objective of this research is to define the differences in adaptation processes of first-year students of engineering and of humanities to university education.

Our hypothesis is that there exists a difference between adaptation of engineering students and adaptation process of students of humanities because of the difference in original skills and competencies. It is obvious that applicants who are admitted to humanities university programs are more aiming at developing skills for the professional area "person-to-person", while the applicants to engineering programs emphasize development of "person-to-machine" skills. Development of the so called people skills allows the humanities students not only to be successful in their professional area, but also to use these skills for adaptation to a new social situation, for example, to a start of their university life.

3 Approach

This research was conducted in Kazan National Research Technological University and Kazan Federal University (Russia) in 2019–2020 where 213 first-year students participated with the average age of 19. From this sample: engineering students – 159 people (43% female), humanities students – 54 people (59% female).

In order to study all the elements of the adaptation process we used the questionnaire which allows to determine the adaptation level of students to university life which was developed and tested by us in 2018 [9]. This method is based on the idea of a comprehensive approach to studying students' adaptation in a university. The literature search allowed us to define several adaptation types: physiological adaptation, social and cultural adaptation [7]; socio-psychological adaptation [3, 6, 11, 12]; academic adaptation [8]. As a result, the questionnaire has four scales which assess the four types of students' adaptation to university life: "physiological adaptation", "social and cultural adaptation", "socio-psychological adaptation", and "academic adaptation". We shall now elaborate on these scales in more detail:

1. Physiological adaptation – is a set of physiological specific traits which determine how a human body compensates for the changes in environment (water, food, climate, time zones). For students these are – the study-life balance, the local climate, the prevailing level of activity and correlation of functional systems, body organs and tissues, as well as body control mechanisms which ensure a student's normal body functioning during the academic year [5].
   A person's adaptation to a new environment and the resulting emotional and psychological tension along with the climate change cause psycho-physiological difficulties. Therefore, the physiological adaptation covers the following factors: physical well-being from the very start of university studies, the study schedule, sleep and nutrition during the time at a university, the level of comfort of the study premises, the health condition at the start of the university training.
2. Academic adaptation characterizes the maximum degree of a person's ability to adjust to education in a particular institution, in particular: the ability to acquire knowledge, skills, and competencies in the new educational environment; adoption of the university's testing system, self-education forms and skills, rationally organizing his own study process. This aspect of adaptation helps to develop certain personality traits in first-year students: orientation towards the goal, hard-working, responsibility, discipline, and attention.
   Within the framework of academic adaptation we deal with interest to courses taught at the university, the ability to display your individual character, perceptiveness to the study material of a particular training program, good time-management of individual work during university studies, the ability to read and understand scholarly and scientific literature, the ability to make presentations during classes, readiness to perfect one's professional aptitude.
3. Our definition of social and cultural adaptation is based on the understanding that this adaptation type deals with person's compatibility with the new cultural environment (the feeling of harmony and well-being in a foreign cultural environment) [14]. We measure the academic adaptability scale by questions from the following themes: how well-informed is the student about social and cultural life of his university, does he take interest in social and cultural events in the city, whether the local everyday life has something interesting to offer, whether he participates in certain activities in his free time (music, sport, dancing, socializing), whether he takes steps to learn about the local history and culture in the city of the university's location.
4. Socio-psychological adaptation comprises two parts: social and psychological. Social adaptation describes how a person establishes his social connections in a

group where the person can productively perform his tasks without long-lasting external and internal conflicts, can satisfy his sociogenic needs, meets the social role expectations which his group imposes on the person, goes through self-affirmation and free expression of his creative potential. Due to the fact that higher education groups students together, students' adaptation is immediately connected with their position in these groups: a student, a student group and the student society are all active participants of this process [18].

Psychological adaptation is a process of a student's psychological preparation based on his attention span, memory, cognition, will power; is determined by the student's active personality, and acts as the means of accommodation (learning and conforming to the environment's rules) and assimilation. The questions on the socio-psychological scale of the questionnaire touch on the following themes: emotional well-being from the start of the university training, interest in one's fellow-students, level of emotional comfort among other students, a student's activity level in a group, help and support from one's peers, emotional atmosphere in a student group, number of social contacts with other students at the university.

The questionnaire which measures students' adaptation to university life contains 25 questions answers to which are assessed according to the 7 point Likert scale. At the end of the questionnaire we compute the average score on each adaptation scale and the general level of adaptation which is an integral indicator of students' adaptation to life at university [9]. The statistical analysis of the questionnaire answers was performed on the STATISTICA software.

4 Actual Outcomes

The statistical analysis shows material differences between the engineering and humanities students on the academic adaptation and general adaptation scales (according to the Kholmogorov-Smirnov criterion).

Table 1. Comparison of average scores of the students' adaptability questionnaire scales between the engineering and humanities students (according to the Kholmogorov-Smirnov criterion)

Adaptation	Average score of the engineering students (n = 159)	Average score of the humanities students (n = 54)	Statistical confidence level of the differences between the two groups of the students (p-level)
Social and cultural	4.53 ± 1.03	4.76 ± 1.21	$p > 0.10$
Physiological	4.81 ± 0.82	5.06 ± 1.00	$p < 0.10$
Socio-psychological	5.02 ± 0.89	5.19 ± 0.90	$p > 0.10$
Academic	4.79 ± 0.81*	5.12 ± 0.99*	$p < 0.005$
General level of adaptation	4.79 ± 0.69*	5.04 ± 0.86*	$p < 0.005$

Note: * - statistically material differences between the groups

As the data from Table 1 shows, the average of each adaptation scales is higher among the humanities students. Moreover, the differences on academic adaptation and general level of adaptation are of statistically material character. Therefore, we can claim that the students of humanities in general assess their adaptation level higher than their peers from engineering programs. This might be brought about by a number of factors, in particular, by different levels of complexity of humanities and engineering programs. On the other hand, the adaptation process may be influenced by the level of social skills which can be more developed in students of humanities. Therefore, this fact needs further researching.

Influence of the gender factor on adaptation showed absence of statistically material differences in adaptation levels of male and female students. This could mean that this factor is of little influence on adaptation process. In other words, in adaptation to life at a university the gender does not play a significant role, but rather the engineering or humanities profile of a student's training. The comparison between male student of engineering and humanities and female students of engineering and humanities show such differences, as we can see in Tables 2 and 3.

Table 2. Comparison of average scores of the students' adaptability questionnaire scales between the male engineering and humanities students (according to the Kholmogorov-Smirnov criterion)

Adaptation	Average score of male engineering students (n = 89)	Average score of humanities male students (n = 22)	Statistical confidence level of the differences between the two groups of the students (p-level)
Social and cultural	4.34 ± 1.09*	4.82 ± 1.3*	$p < 0.05$
Physiological	4.8 ± 0.89	5.11 ± 0.99	$p > 0.10$
Socio-psychological	4.9 ± 0.96	5.19 ± 0.82	$p > 0.10$
Academic	4.73 ± 0.82*	5.00 ± 0.94*	$p < 0.025$
General level of adaptation	4.69 ± 0.76	5.03 ± 0.82	$p < 0.10$

Note: * - statistically material differences between the groups

Based on Table 2 we can conclude that statistically confident differences can be observed in Social and cultural adaptation and Academic adaptation scales between male students of engineering and humanities programs (according to the Kholmogorov-Smirnov criterion). The average scores of Social and cultural adaptation of these two groups of students are 4.34 and 4.82 respectively. The average scores of Academic adaptation of these two groups of students are 4.73 and 5.0 respectively.

Table 3. Comparison of average scores of the students' adaptability questionnaire scales between the female engineering and humanities students (according to the Kholmogorov-Smirnov criterion)

Adaptation	Average score of female engineering students (n = 69)	Average score of humanities female students (n = 32)	Statistical confidence level of the differences between the two groups of the students (p-level)
Social and cultural	4.80 ± 0.89	4.73 ± 1.17	$p > 0.10$
Physiological	4.87 ± 0.71	5.03 ± 1.03	$p > 0.10$
Socio-psychological	5.20 ± 0.77	5.20 ± 0.97	$p > 0.10$
Academic	4.88 ± 0.81	5.20 ± 1.04	$p > 0.10$
General level of adaptation	4.94 ± 0.57*	5.04 ± 0.91*	$p < 0.05$

Note: * - statistically material differences between the groups

Comparison of the female students' scores of engineering and humanities programs also show statistically confident differences in general adaptation level of 4.93 and 5.04 respectively (Table 3). This data illustrate the fact that in general male and female students of humanities programs rank higher their adaptation levels which may evidence of their more successful adaptation to studying at a university.

Table 4. Comparison of average scores of the students' adaptability questionnaire scales between the male and female engineering students (according to the Kholmogorov-Smirnov criterion)

Adaptation	Average score of male engineering students (n = 89)	Average score of female engineering students (n = 69)	Statistical confidence level of the differences between the two groups of the students (p-level)
Social and cultural	4.34 ± 1.1*	4.79 ± 0.88*	$p < 0.025$
Physiological	4.79 ± 0.89	4.87 ± 0.70	$p > 0.10$
Socio-psychological	4.90 ± 0.95	5.20 ± 0.77	$p < 0.10$
Academic	4.73 ± 0.82	4.87 ± 0.80	$p > 0.10$
General level of adaptation	4.69 ± 0.75*	4.93 ± 0.57*	$p < 0.05$

Note: * - statistically material differences between the groups

Interestingly enough, while gender differences seem not to affect the adaptation process in general, we still could detect some variations in the engineering group. As we can see in Table 4, there exist confident differences between male and female students of engineering programs on the average score of social and cultural adaptation (4.34 and 4.79 respectively) and on the level of general adaptation according to the Kholmogorov-Smirnov criterion. At the same time, comparison of male and female humanities students did not show any statistically confident differences. We may conclude that male and female humanities students are more homogenous in their adaptation to life at a university.

5 Conclusions

In general, self-assessment of adaptation level among the engineering students (regardless of the gender) is lower than among the humanities students across all the adaptation scales. As this research has shown, the lowest score of general adaptation was observed among the male engineering students. We could detect statistically confident differences between the adaptation levels of first-year students of engineering and humanities programs on the Academic adaptation scale and on the General adaptation scale. Moreover, the male students following engineering or humanities programs manifested statistically confident differences on the Social and cultural adaptation scale. We did not detect any significant influence of the gender on the adaptation process; it has some influence only within the group of engineering students.

These results confirm our hypothesis that adaptation process of engineering student differs from that of humanities students. This is important to take into consideration when designing the curricula for engineering programs. Academic adaptation of male and female engineering students can be improved in the following indicators: the ability and skills of displaying your own individuality; good time-management; the ability to read and understand scientific and scholarly literature; the ability to make presentations in front of an audience etc. These skills can be developed by following courses in social sciences and humanities [17], by employing interactive teaching methods in technical subjects: open discussions and debates, presentations, teamwork, joined creative projects, special courses on good time-management and studying skills [1, 10]. Development in future engineers of social interaction skills, of teamwork skills, of leadership qualities helps not only if facilitation of student adaptation to university life, but also, as is shown by analysis of engineering education trends, may become an important part of the "soft-skills" of a future engineer [15].

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The Role of Metacognition and Critical Thinking for Engineering Students in EFL Learning

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Abstract. As students of technical universities are increasingly integrating into a unified educational space, they are faced with the need to assimilate and process foreign-language information in solving cognitive and professional items.

This study aims at identification of the relationship between metacognitive skills, critical thinking and the success of mastering the foreign language. For this, a pilot study with students of Kazan National Research Technological University (Russia) and students of the University of Isfahan (Iran) in the total amount of n = 376, was conducted. To assess metacognition, the Metacognitive Awareness Inventory (MAI) by G.Schraw and R.S.Dennison in the adaptation of A.V.Karpov and I.M.Skityaeva was used. To evaluate critical thinking, a questionnaire was developed based on Holistic Critical Thinking Scoring Rubric (HCTSR) indicators by Peter A.Facione and Noreen C. Facione. As a criterion for the success of training, we used students' grades in English (L2) over the previous semester. In addition to this criterion, the students gave a self-assessment of their level of English proficiency.

The obtained results reveal that the success of learning English has statistically significant relationships with the level of critical thinking and the level of some indicators of the metacognitive awareness. Consequently, the development of critical thinking, as well as the reflection of one's own cognitive abilities, will contribute to improving English academic performance.

The pilot study showed also that the success of mastering a foreign language is impossible without considering the context of the situation in which the student is. Environmental conditions, in particular the relevant activities where knowledge of a foreign language is necessary, can encourage a student to master a foreign language and develop critical thinking and metacognitive skills.

Keywords: Metacognitive skills · Critical thinking · EFL learning · Higher education

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1 Introduction

As students of technical universities are increasingly integrating into a unified educational space, they are faced with the need to assimilate and process foreign-language information in solving cognitive and professional items. Therefore, the success in EFL Learning (L2) could determine students' academic success. English Proficiency is also a prerequisite for success in research activity, where most publications are in English, and for future professional activity, as the engineering profession embraces versatile professional activities that imply involving in international teams and multinational companies.

The success of mastering an L2 is influenced by many factors including cognitive ones. In today's fast-changing world, the so-called higher-order skills (such as metacognition and reflection, and critical thinking) become very important. They allow the individual to be more adaptive and flexible to respond to emerging challenges. In the last decade, there has been an increase in research in this area. It is believed that students who successfully use metacognition and critical thinking are the most successful students [32], so universities declare that the development of these skills is one of the main goals of higher education. Nevertheless, purposeful development of these skills is challenging and difficult. This problem is one of the leading problems of the modern education system, since "the traditional paradigm of education, which has been preserved to this day, is oriented, first of all, to the transfer of ready conclusions of science by giving (by a teacher or teaching aids - textbooks and programs) facts, patterns, principles and rules, instead of teaching students to independently discover these principles and rules, i.e. to teach techniques and methods for solving problems, tasks [24]. Often metacognition and critical thinking are formed as a "by-product" of learning, or they arise under the influence of the environment and culture in which the individual is included. Research in this area is not enough, despite the high importance and relevance of the problem. Therefore, this study aims at identifying the possible relationship between the proficient use of metacognitive strategies and success in foreign language learning by Persian and Russian students. The study is based on the following hypothesis: success in EFL learning is associated with metacognition and critical thinking.

The purpose of the article: to reveal the relationship of metacognition and critical thinking with the success of a student foreign language mastering.

2 The Interrelation of Metacognition and Critical Thinking

Two pioneers in the study of metacognition are A.L.Brown and J.H.Flavell. Metacognition is defined by Flavell as 'cognition of knowledge' and is expressed in the control, interpretation, evaluation and regulation of the content and process of one's own cognitive activity [12]. L.J.Moses and J.A.Baird agree with this, noting that this is a broad term that encompasses knowledge and regulation of cognitive activity [29]. Metacognition is a complex construction consisting of some components. In particular, A.L.Brown and J.H.Flavell distinguish two main components of metacognition. The first component is "knowledge about cognition", i.e. the individual's knowledge of her/his knowledge and the boundaries of this knowledge, as well as the knowledge of knowledge acquisition strategies. The second component, "the regulation of cognition," is associated with the activity of acquiring knowledge and regulating the cognitive activity. Knowledge of cognition, according to the authors, includes three subprocesses, which contribute to the reflective aspect of metacognition: 1) declarative knowledge (i.e. knowledge about strategies); 2) procedural knowledge (i.e. knowledge about how to use strategies) and 3) conditional knowledge (i.e. knowledge about when and why to use strategies). The regulation of cognition includes a number of subprocesses that facilitate the control aspect of learning, including planning, information management strategies, monitoring understanding, debugging and evaluation strategies [2, 3]. Cognitive psychology researchers associate metacognition with a number of other psychological phenomena, such as meta-memory, critical thinking, and motivation [27, 33, 35, 41, 42].

A large number of publications are devoted to the relationship between metacognition and critical thinking. Metacognition is seen as a condition for critical thinking, since reflection of one's thought process increases the likelihood that an individual will engage in critical thinking [19, 23]. One of definitions of critical thinking views it as "reasonable and reflective thinking [concerned with what to do or believe]" [31, p. 3]. In other words, critical thinking is the cognitive process used to acquire knowledge. Critical thinking contributes to a deeper understanding of the things a person faces. Therefore, critical thinking can be considered as a metacognitive process, consisting of a number of additional skills: analysis, evaluation and inference. P.Facione believes that critical thinking skills can be expressed as "interpretation, analysis, evaluation, inference, explanation, and self-regulation" [10]. Friedrichsen considers critical thinking in a similar way; in his opinion, it activates the skills of analyzing and evaluating evidence, defining questions, inference, understanding the consequences of arguments [13]. Thus, there is no common understanding of the mechanism of critical thinking. On the one hand, critical thinking is regarded as a metacognitive process, but on the other hand, this type of thinking is based on metacognition, which implies many possibilities for interpretation of these phenomena.

Many researchers have suggested that cultural differences may influence the critical thinking performance [22, 25]. Grosser, M.M. and Lombard, B.J.J. note that the emphasis on the individual nature of cognitive development has led to a disregard for the cultural context in the development of cognitive abilities and suggest a cultural approach to the development of critical abilities as opposed to an individual approach [14]. At the same time, some authors question the assumption about the influence of culture on the fundamental aspects of critical thinking [30]. Despite the large interest in this issue, the influence of culture on critical thinking and its instruction is not clear. Most studies are based on comparing the critical thinking abilities of foreign students and local students, who study at the same university, but are representative of different countries and cultures. However, in this case foreign students are in a stressful situation (they live in a foreign country and study in a foreign language, which, as a rule, they are not fluent in). And it is precisely this fact that determines the differences in the results of surveys of the level of critical thinking of foreign students and local students. The same conclusion was reached by V.M.-C.Lun, R.Fischer and C.Ward, noting that "we should pay attention to the fact that English language proficiency, but not dialectical thinking style, explained the difference. In other words, the difference in critical thinking appears to be more of a linguistic issue rather than a cultural issue" [22].

In addition, a student, immersed in a new culture, learning a language and daily communicating with classmates and teachers, is affected by these factors, discovers and assimilates new norms, including norms of thinking. This also does not give the purity of the experiment and the ability to evaluate the cultural differences correlated with critical thinking.

As a result of a study, A.Jones came to the conclusion that "critical thinking was limited not by cultural background but by context. The subject coordinator was instrumental in establishing the context for the critical thinking task. From the students' remarks, it is clear that their understanding of critical thinking in this context was strongly influenced by the conceptualisation of critical thinking outlined by the subject coordinator" [17].

The present study presents a unique opportunity to study students from Iran and Russia who are at a home country in a native culture and are studying in a native language, i.e. they do not experience the influence of a stressful situation or other factors that can distort the results of tests, survey or other types of instruments.

Recently, interest in the applied capabilities of metacognition has increased markedly, in particular, as one of the reliable indicators predicting success in educational activities. Modern research has emphasized the importance of using the learning situation to form cognitive and metacognitive skills and strategies. [4, 7, 21, 26, 28, 37, 39, 40]. In addition, the conditions and factors that affect metacognition or have a correlation with it are also considered. For example, the relationship between creative tasks and metacognition has been studied [15, 16]. Other researchers [8] studied the relationship of metacognition and academic achievement of students. The issues of metacognition and self-regulation of students are considered by R.Spruce and L.Bol [38].

Success in mastering a foreign language is also associated with metacognitive skills and strategies. Empirical studies show that teaching students reading strategies can facilitate understanding of a foreign language text [6]. Furthermore, studies show that using self-regulated strategy development (SRSD) helps improve reading comprehension [33]. There is also a correlation between the written competence of students and their ability to self-regulating the cognitive processes, as measured by two MAI factors (knowledge of cognition and regulation of cognition) [11].

3 Procedure and Methods

To study the interrelation between the success in mastering a foreign language and higher-order skills, a pilot study was attended by students of Kazan National Research Technological University (Russia) and students of the University of Isfahan (Iran) in the total amount of n = 376; 34% of them being male and 66% female.

For the survey, Google Forms were used. To assess metacognition, the Metacognitive Awareness Inventory (MAI) by G.Schraw and R.S.Dennison in the adaptation of A.V.Karpov and I.M.Skityaeva was used. The inventory consists of 52 statements, each assessed by the respondent on a 5-point scale. The total value of the inventory on metacognitive awareness is determined by two groups of scales – "knowledge of cognition" and "regulation of cognition". The first group "Knowledge of cognition" includes three scales: 1) *Declarative knowledge*: knowledge of one's skills, intellectual resources and abilities as a student; 2) *Procedural knowledge*: knowledge of how to implement training procedures (for example, strategies); and 3) *Conditional knowledge*: knowledge of when and why to use training procedures. The second group includes five subscales: 1) *Planning*: planning, setting goals and allocating resources before training; 2) *Information management*: the skills and sequence of strategies used online for more efficient processing of information (e.g. organization, development, synthesis, selective focus); 3) *Monitoring*: learning or strategy evaluating; 4) *Debugging*: strategies used to correct errors of understanding and performance; and 5) *Assessment:* analysis of the effectiveness of the strategy after the training episode. The total value of the Metacognitive Awareness Inventory was obtained by adding up the results of all subscales.

To evaluate critical thinking, a questionnaire was developed based on Holistic Critical Thinking Scoring Rubric (HCTSR) indicators by Peter A.Facione and Noreen C. Facione. Assessment of critical thinking was carried out by the self-assessment method. For this, respondents were offered 6 statements based on criteria of the 4th level of development of critical thinking (the highest). Respondents rated each statement using a 10-point Likert scale. The total score for all six statements determined the level of self-esteem of critical thinking.

As a criterion for the success of training, we used students' grades in English (L2) over the previous semester. In addition to this criterion, the students gave a self-assessment of their level of English proficiency. The respondents were asked to evaluate their level of language proficiency using a 10-point Likert scale, where a rating of "0" meant "I don't speak English at all" as compared with 10 - "I speak English fluently". Analysis of the data was carried out by software package Staistica.10.

4 Results

The results of calculating the correlation matrix by the Spearman rank correlation method are presented in Table 1. As can be seen from the table, most of the correlation coefficients are statistically significant; this indicates the presence of relationships between the studied parameters. The table shows that the parameter "self-assessment of the English proficiency level" has a direct correlation with the students' grades in English, which indicates an adequate self-assessment by the respondents of their language proficiency level. The average level of correlation may be due to a rather rough university rating system, when a student receives one of three ratings: excellent, good, satisfactory. This does not allow to accurately correlate the 3-point university rating scale with self-esteem on a 10-point scale.

Table 1. Correlation matrix of the relationship between the success in mastering L2 and a higher-order skills.

	Self-assessment of English proficiency	English grade for the previous semester	Critical thinking	Metacognitive awareness
Self-assessment of English proficiency	1.00	0.42*	0.36*	0.17*
English grade for the previous semester	0.42*	1.00	0.26*	0.11*
Critical thinking	0.36*	0.26*	1.00	0.36*
Metacognitive awareness:	0.17*	0.11*	0.36*	1.00
Declarative knowledge	0.17*	0.20*	0.42*	0.78*
Conditional knowledge	0.11*	0.08	0.33*	0.73*
Procedural knowledge	0.13*	0.15*	0.27*	0.71*
Information management strategies	0.12*	0.10	0.27*	0.83*
Debugging strategies	0.10*	0.15*	0.27*	0.73*
Planning	0.11*	0.03	0.26*	0.84*
Integrity monitoring	0.14*	0.01	0.28*	0.84*
Assessment	0.17*	0.02	0.26*	0.81*

* - statistically significant correlations $p < 0.05$.

Let's consider the relationship between the success in mastering a foreign language (L2) and higher-order skills (metacognition and critical thinking). An analysis of the relationship between students' grades in English over the previous semester and Critical Thinking showed a direct correlation between these parameters (the value of the correlation coefficient is 0.26). This suggests that these two parameters are interconnected, i.e. the development of critical thinking will contribute to success in mastering a foreign language. Self-assessment of the level of English proficiency has a higher correlation value (0.36) with critical thinking, which may be due, on the one hand, to a more detailed assessment on a 10-point scale of these parameters, and on the other hand, critical thinking is necessary for self-assessment; therefore, here we see additional influence of critical thinking on self-esteem.

The final value of the metacognitive awareness scale has a weaker correlation with the students' grades in English (0.11) and self-assessment of English proficiency (0.17). Thus, it can be concluded that metacognitive awareness affects the process of mastering the English language, but this effect is insignificant. At the same time, there are MAI subscales that correlate with students' grades in English. In particular, this is the "Declarative knowledge" scale which reflects a student's knowledge of his skills, intellectual resources and abilities as a student (0.20); the scale "Procedural knowledge" - knowledge of how to implement training procedures (0.15). Also, a statistically significant correlation (0.15) with an English grades has the "Debugging Strategies" scale, which implies using a strategy to correct errors of understanding and increase the productivity of mastering the material. Therefore, it can be assumed that the reflection of cognitive capabilities allows the student to choose the optimal strategies in the learning process, error correction in the assimilation of the material and increase productivity in learning English.

Studying the influence of metacognition and critical thinking on the success of learning a foreign language will not be complete if we do not take into account the impact of the environment where a student is located and his motivation. In this case, we identified situations that may prompt a student to master a foreign language. For this, students were asked the question: "Does any of your projects require the English language proficiency?". Based on students' answers to this question, all students were divided into two groups: 1) students who participate in projects where English is required; and 2) students who do not have such projects.

An analysis of the data by using comparing unrelated samples (T-tests) showed that these two groups of students are statistically different from each other in a number of parameters (see Table 2). Moreover, students currently participating in the project, on average, have higher values in all evaluated parameters than students in the second group. Thus, it seems that participation in the projects that require the English language proficiency could increase motivation in learning the language. Such students rate their knowledge of English in higher level, have better critical thinking scores and have a number of statistically significant differences in the level of development of some metacognitive awareness components (see Table 2). The absence of differences on the scale of "English grade for the previous semester", as already mentioned above, is probably due to the low information content of this scale.

The revealed regularity can be explained by the Activity Theory of A.N.Leontyev. According to this theory, activity determines consciousness, and the formation and development of the human psyche takes place in activity. Therefore, the presence of purposeful activity (participation in a project) could lead students to the awareness of the need of the English proficiency, and, thereby, contribute to the emergence of the phenomenon of "shift of the motive to the goal". When the motive shifts to the goal, the goal acquires the status of a new motive [20]. G.W.Allport mentions this phenomenon in his article: "The types of activities and objects that previously entered the game only as a means to the goal, now become goals themselves" [1]. In this particular case, a motive for learning a foreign language appears or intensifies. A new semantic content of the educational activity also appears. In such a case, a student learns a foreign language not because it is a part of the curriculum and someday it will be useful to him, but because he needs it right now and it is necessary for the success of the project. This situation, associated with the need to learn a foreign language, leads to the fact that students begin to use metacognitive strategies more consciously and develop critical thinking based on the goals and requirements of the project. For example, a development of a technical product project in an international group will require the student to have interpersonal communication skills in English and knowledge of technical terms in this area. As a result, a student begins to study such sections of the English language intensively even if initially he did not have such a desire.

Table 2. Correlation between participation in a project requiring English language proficiency and self-assessment of the level of motivation, critical thinking and metacognition.

	Mean for a group of students who do not participate in the project that require the English language proficiency (n = 244)	Mean for a group of students who participate in the project that require the English language proficiency (n = 134)	t-value	Statistical level of significance of differences between groups of students (p-level)
Evaluate your English language proficiency	4,03 ± 1,99*	5,16 ± 2,07*	−5,24002	0,000000
Evaluate your desire (motivation) to learn English	6,74 ± 2,78*	7,62 ± 2,16*	−3,17962	0,001597
What was your English grade for the previous semester?	4,27 ± 0,65	4,33 ± 0,63	−0,77596	0,438258
Critical thinking	5,88 ± 2,02*	6,78 ± 1,76*	−4,32346	0,000020
Metacognitive awareness:	192,82 ± 27,55*	200,75 ± 26,24*	−2,72250	0,006781
Declarative knowledge	30,28 ± 4,88	30,93 ± 4,21	−1,30679	0,192082
Conditional knowledge	19,74 ± 3,08	19,75 ± 2,87	−0,01381	0,988985
Procedural knowledge	14,85 ± 2,62*	15,45 ± 2,44*	−2,17656	0,030135
Information management strategies	37,11 ± 6,02*	38,49 ± 5,30*	−2,22478	0,026689
Debugging strategies	19,91 ± 3,08	20,30 ± 2,99	−1,18546	0,236584
Planning	25,21 ± 4,78*	26,64 ± 5,01*	−2,74151	0,006408
Integrity monitoring	25,65 ± 4,42	27,11 ± 4,22*	−3,13133	0,001876
Assessment	20,07 ± 4,90	22,07 ± 4,22*	−3,98928	0,000080

* - statistically significant correlations $p < 0.05$.

Thus, considering the influence of metacognition and critical thinking on the effectiveness of mastering a foreign language, it is necessary to take into account the influence of motivation and participation in different types of activities. In this case, the student's current participation in a project, where English proficiency is necessary, enhances his motivation to master a foreign language, encourages the development of critical thinking as well as metacognitive skills, in particular, procedural knowledge, information management strategies and planning. However, in order to talk about this as a regularity, it is necessary to conduct an additional study to compare the initial level of development of these parameters among students of two groups before starting work in the project.

5 Conclusion

The success of learning English has statistically significant correlations with the level of critical thinking and the level of some indicators of the metacognitive awareness. Consequently, the development of critical thinking, as well as the reflection of one's own cognitive abilities, could contribute to improving academic performance in English. However, premature conclusions should not be made about the impact of critical thinking on the level of language acquisition. Often, university rating, although it correlate with the level of English proficiency, does not accurately reflect it. Therefore, further study of this issue is necessary using more accurate, specialized tools for assessing the level of foreign language proficiency than the university rating system and self-assessment (for example, the Oxford Placement Test).

Studying the correlation between metacognition, critical thinking and the success of mastering a foreign language is impossible without considering the context of the situation in which the student is. Environmental conditions, in particular the relevant activities where knowledge of a foreign language is necessary, can encourage a student to master a foreign language and develop critical thinking and metacognitive skills.

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Modern Pedagogical Techniques in Teaching French to Prepare Engineering University Students for Academic Mobility

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Abstract. The paper focuses on the practice of preparing Kazan National Research Technological University students for academic mobility to universities of France and development of a language training program to facilitate the students' academic mobility. Every year, several KNRTU students, after completing the undergraduate studies, leave to do the Masters at French universities. In order to better prepare students for academic mobility to French universities, French teachers have developed a special training program, aiming to make it easier for students to continue their studies at universities and everyday life in France. The paper shows the methodology of the educational program of preparation for academic mobility. Besides, KNRTU French teachers have developed a program to prepare students for international DELF (B1, B2) exam to gain an international diploma, as students have the right to study at French universities only with these international diplomas. The paper discusses the pedagogical technologies that are used at French classes to prepare students for academic mobility, namely: multi-level training, problem-oriented learning technologies, collaborative training, project-based studies, game-based learning technologies, information and computer technologies. The teacher should choose such teaching methods that would allow the students to show their activity and master the practical aspects of a foreign language.

Keywords: Pedagogical techniques · Academic mobility · Profession-oriented communication · Training program

1 Context

Integration processes in the world community in all areas of human life have also affected the system of higher education. Today, Europe is paying considerable attention to the mutual recognition of academic degrees and international cooperation in science and education, which is very important for Russian universities. In course of Russian universities' integration into the international educational space, an important role is played by students' academic mobility, which helps improve the quality of education, enhance understanding between different cultures and peoples. The academic mobility of students to French universities is constantly developing and the number of foreign students is constantly growing, including students from Russian universities. Also, a demand has arisen in specialists who during their university studies not only received a

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good professional education, but also mastered foreign languages well enough to successfully compete and fulfil their potential in modern market conditions [1, 2].

2 Purpose

This work aims at analyzing modern pedagogical techniques in teaching French to prepare the students of Kazan National Research Technological University (KNRTU) for academic mobility to French universities. French classes at the University are based on educational programs and plans specifically designed for academic mobility. The paper shows that the special point of teaching a foreign language for academic mobility is that we teach speech skills and develop the students' ability to use a foreign language as a means of communication and achieving certain goals. The teacher should choose such teaching methods that would allow each student to show their activity and master the practical aspects of a foreign language. The paper considers pedagogical technologies that are used in French classes to prepare for academic mobility, and examples of their application.

3 Approach

Every year, KNRTU students go to do the masters at French universities. In order to better prepare the students for academic mobility and to make the students' university studies and everyday life in France easier, a special academic mobility preparation program has been developed. The teachers have developed this educational program taking into account the new realias and opportunities of the modern society. The academic content is based on the principles of competence approach. They are supposed to be diversifiable, taking into account the level of the students' linguistic skills. Linguistic and methodological content of language training of students, based on the competence approach, is crucial for students' successful integration in French universities. During practical classes, the students are told about the system of education in France, its strengths and weaknesses, it is compared with the system of education in Russia. They study a professionally oriented French, in particular, the concepts and terms that are known to students in the language of their major. The students complete numerous tasks using texts on physics, chemistry, mathematics, etc. In addition, the students learn to make presentations on their major, translate specialized texts, render them, make summaries, make reports, read mathematical formulas, tables and diagrams in French, and much more. During classes, teachers demonstrate videos with excerpts of lectures on physics, mathematics, chemistry, etc., which are read by French teachers at universities.

Our students learn to make notes of these lectures, which is very difficult, because French teachers do not pause to allow students to do this, as it is in Russian universities. At first, students do not manage to make notes of lectures in French, but as they learn, they start understanding the basic principles of note-taking and at the end of training they successfully cope with this task. Besides, when French scientists and teachers of chemistry, physics, engineering pedagogics, etc. come to the University to participate in conferences, workshops and master classes, teachers of French of the Department of Foreign Languages for Professional Communication invite them to academic mobility training classes. French scientists and teachers explain to students how theoretical and practical classes are held at French universities, talk about the system of higher education in France, about scientific and production internships at French enterprises, about how to write master's graduation papers and academic articles. All this is of great interest to students. In this manner, teachers of French prepare students for academic mobility according to a specially designed program, motivating them to enter French universities, trying to facilitate their daily life and study in France in the future.

The challenges that are most often encountered by students in France, as a rule, include: cultural and contextual in relations with other students, teachers, administration; linguistic at the level of specialty language and various situations of university communication (verbal comprehension, understanding lectures, documents on the chosen discipline, written papers, etc.); methodological problems (for example, taking notes of lectures). All these difficulties are discussed during practical classes in French with explaining the algorithm to overcome them.

In addition, a program was developed to prepare students for international DELF (B1, B2) exam to gain an international diploma, as students have the right to study at French universities only with these international diplomas. These levels of French ensure understanding lectures and practicals, provide an insight to the organizational and administrative university system, allow mastering writing (to make notes during lectures, write an analysis, comments, essays, etc.). While studying at a French university, a student must understand the conditions of exams, the tasks content, understand texts within his field of expertise, and have academic speech skills (report, presentation, defense, etc.).

Each of these specialized competences is reflected in the Common European Framework of Reference. Thus, the descriptors of common European competences related to understanding lectures are formulated as follows:

- I understand a lecture or conversation on my professional subject, provided that the subject is familiar, and the speech itself is simple and has a clear structure (level B1).
- I understand the main theses of the complex in linguistic and semantic content speech on specific or abstract topics, uttered in a normative dialect, including technical discussions on topics within my field of activity.
- I am able to follow a long report or a complex system of evidence, provided that the topic is familiar enough to me and the change of message is indicated by appropriate markers.
- I understand the main theses of lectures, talks, reports and other types of thematically and linguistically complex speech related to educational professional activities (level B2).
- I can follow a long report, even if it is characterized by a fuzzy structure and the ratio of parts to each other is not expressed explicitly, but only implied.
- I have almost no difficulty in understanding lectures, debates, and discussions (level C1) [3, 4].

The descriptors of European competencies allow building a system of language training in such a way as to bring it as close as possible to the requirements that apply to a student of a French university, which contributes to integration of students into foreign university environment. All these competencies are taught by teachers of French in preparation for academic mobility to French universities.

In this regard, French Teachers of KNRTU stimulate interest of students to pass the international examination DELF/DALF and to obtain international certificates on French. Students of KNRTU successfully pass these examinations and receive B1, B2 levels.

At practical French classes for academic mobility, various pedagogical technologies are used, among which special attention is paid to the following: multi-level training, problem-oriented learning technologies, collaborative training, project-based studies, game-based learning technologies, information and computer technologies. The pedagogical techniques of teaching French for academic mobility are briefly presented below.

3.1 Multi-level Training

Multilevel training is a pedagogical technique to organize an educational process that consists of different levels of learning, different levels of training that enables each student to master academic material at a level depending on the abilities, capabilities, and individual features of a student's personality; it is a technique in which a student's activity evaluation criterion is his efforts to master the material, its creative application [5].

Teaching French is often associated with problems due to the heterogeneity among the students in one group: according to their educational opportunities, individual abilities, interests, and the initial level of knowledge of the French language. The solution to these problems is facilitated by the internal differentiation within the student groups, which is the basis of the multi-level training technology. Solving these problems is facilitated by internal differentiation of student groups, which is the basis of technology of multi-level training. The main focus in multilevel training is on the division of students according to their ability or level of training, this is achieved through: 1) choice of educational material, in which each level is offered depending on the individual abilities of students; 2) providing students with opportunities to select educational materials, learning method, and the appropriate level of training independently [6, 7].

Here is an example of multi-level training in preparation for academic mobility. The group is divided into subgroups of 3–4 according to their level of training. The whole group is working on the same theme "First day in France". Together, they develop a plan to come to France, accommodation in a dormitory, and acquaintance with a French university. Each subgroup is given the task to prepare their part: to plan a route from the accommodation town to the city where their French university is; to plan a route to the dormitory where the students will live; to prepare all documents required dormitory accommodation, to plan a route from the dormitory to the university; to prepare all documents required by the University, etc. Based on the results of the joint work of individual subgroups and the whole group, the material is mastered. During the work, the subgroups communicate with each other in course of collective discussion, ask each other questions, clarify details, and offer their own options. It should be noted that all the topical vocabulary is learned at previous classes. Therefore, this lesson is devoted to conversation practice and communication.

3.2 Problem-Oriented Learning Techniques

The idea of problem-oriented learning is based on the commitment to strengthen the role of the student in education, awareness of the importance of personal development, acquisition of expertise, knowledge, and skills by the students [8]. In turn, the teacher directs and guides the process of resolving problem situations, and due to increasing independence and personalization of the knowledge received, students master this knowledge deeper and the educational process is activated due to a greater interest on the part of the students.

Problem-oriented learning is based on simulating a real creative process by creating a problem situation and finding a solution to it [9]. There are various ways to create problem situations: bringing students to a contradiction and suggesting that they should find a solution themselves; clashing contradictions in practice; presenting different points of view on the same issue; offering to consider a phenomenon from different points; encouraging them to make comparisons, generalizations, and conclusions.

The main goals of problem-oriented learning include: meaningful learning of the system of knowledge and methods of mental and practical activity by the students; development of cognitive independence and creative abilities of students; the formation of a scientific worldview based on independently verified evidence of scientific concepts and provisions [10, 11].

A problem situation is a kind of interaction in which there is a conscious difficulty and the ways to overcome it require the search for new ways of action and knowledge.

As part of our academic mobility training, we offer students a variety of problem-based situations. Let us make an example. At French universities, foreign students are provided with preparatory French courses during their study at the university. Students are offered a problem-based situation - to choose a place and method of study. The following places are offered: the Foreign Students Department, the International Relations Department, the language center, the French language resource center. Methods of training: intramural and remote. Students should analyze these places and ways of learning and choose where they prefer to study and explain why.

3.3 Collaborative Training

The main problem in teaching French is the lack of active oral practice per student during classes, the lack of necessary differentiation and individualization. The specificity of foreign language as a discipline, as you know, is that we teach not the basics of science, but skills in various speech activities. The French language training goal is to master the communicative competence, i.e. training should be rather focused on the practical mastery of the French language than on the language system (linguistic competence), especially if the student's goal is to go to study abroad.

The main point about collaborative training is to make the student, not the teacher, the center of learning, the activity of learning, not teaching. If we teach practical proficiency in one or another speech activity, we can only teach it through practice in this activity. A significant part of the class time should be devoted to students' speaking.

This is why the experience in collaborative training is of great interest. These techniques allow achieving learning goals effectively and unlocking the potential of each student. Taking into account the specificity of the foreign language as a discipline, these pedagogical techniques ensure the necessary conditions for activating the cognitive and speech activity of each student in the group, allowing each student to realize, comprehend new language material, have sufficient oral practice to form the necessary skills.

The concept of collaborative training is about creating conditions for active collective training activities of students in various educational situations [12]. Students' abilities are different - some of them are quick to understand the teacher's explanations, easily master vocabulary and communication skills, while others need much more time to understand the material and even additional explanations. If such students are grouped into teams of 4–6 people and given one collective task, explaining the role of each student in the team when performing this task, then a situation is created where everyone is responsible for the entire team's result, and not just for the result of his/her own work, which is especially important. So, low-performing students find out all the aspects they don't understand from brighter ones, and the latter need all the members of the group, especially the weak ones, to understand the material. Each group should include low-, medium-, and high-achieving students in terms of the language level, both girls and boys. They work together to bridge the skills gaps. This is the central idea of collaborative training.

Here is an example of collaborative training. Students are divided into groups of 4–6 to work on educational materials, which are divided into logical blocks. For example, working on the topic Organization of Master's Studies at French Universities consists of the following sub-topics: organization of lectures, organization of practical classes, writing notes, examination session, etc. Each student finds material on his/her own topic. Next, students who study the same topic but are in different groups meet and exchange information as specialists on the topic. Then they come back to their groups and teach what they have learned from other students. They, in turn, talk about their question. All communication is in French. Students are motivated to have their groupmates diligently complete their task, as this may affect their final grade. The topic is reported on individually and by the entire group as a whole. At the final stage, the teacher can ask any student in the group to answer any question on this topic. Questions are asked not only by the teacher, but also by members of other groups. Students of the same group can supplement their groupmate's report.

The focused follow-through collaborative work allows you to significantly increase the time of oral practice for each student in the class.

3.4 Project-Oriented Techniques

Recently, project-oriented techniques are widely used in teaching foreign languages. Project-oriented techniques allow developing students' creative abilities, the ability to independently apply their knowledge to solve practical problems, analyze information, and navigate a huge flow of information. Project technologies provide for the use of problem, search, and research methods aimed at solving real results [9]. During classes in foreign language it is necessary to teach students to express their thoughts in the studied language, to talk about the tasks assigned to them so that students pay attention to the content of their speech, and foreign language acted as a function of forming these thoughts. The use of project-oriented techniques helps solve this problem.

There are the following approaches to structuring a project: goal setting (defining the topic, problem, hypothesis, project goals); planning (defining research methods, sources of information, evaluation criteria); research (collecting information, solving intermediate tasks); presentation (defense) and evaluation of results (qualitative assessment of the work done) [13, 14]. Of particular importance is the defense of projects involving the analysis of project activities, including self-assessment and mutual assessment. The results of the collective work of students are summed up, and the work done is evaluated. Students study information in a foreign language and provide an additional point of view on the solution of the problem. The students' ability to see their actual language proficiency can be a significant incentive for further or more in-depth study of French.

Here is an example of project-based techniques. The students are given a task to write a term paper on a topic within their specialty, since at French universities students write a lot of term papers and our students must be able to write term papers in French correctly. Then the students defend their course paper in front of the entire group, the teacher checks the work, corrects mistakes, and makes comments.

So, project-oriented techniques are apparently one of the most effective ways to develop and educate students able to navigate the information space. These techniques reveal the students' intellectual, creative, and spiritual potential, increase their motivation to learn a foreign language.

3.5 Game-Based Techniques

Training games are used in study as one of the forms of organizing a speech situation. Training game is based on students' verbal communication according to a plot and allocated roles. Game is a specially organized activity that requires the stress of emotional and mental forces [15]. At foreign language classes, games are divided into grammatical, lexical, spelling, phonetic, and creative.

The time and place of games in classes depend on several factors: goals, tasks of the class, the material studied, students' training level, etc. Game can be used as a training exercise for primary consolidation of the material, as well as for revision. A game can be played at various stages of the lesson. However, for all the effectiveness and attractiveness of games, a sense of proportion should be observed, otherwise they will tire students and will not give the expected result.

Game-based learning technologies are motivational, as they raise the need to communicate in a foreign language and are a model of interpersonal communication. Training game determines the choice of language tools, promotes the development of speech skills and abilities, allows modeling students' communication in various speech situations; in other words, role-playing game is an exercise for mastering skills and abilities of dialogical speech in interpersonal communication [16, 17]. In this case, game is a training function.

There are the following categories of pedagogical games: cognitive, educational, training, controlling, educative, generalizing, developing, productive, reproductive, communicative, diagnostic, creative, career-guiding, psychotechnical [13, 18]. According to the organization of the game methodology, there are business, story, subject, role-playing, and imitation games. In contrast to simple games, teachers have a clearly defined learning goal that corresponds to the pedagogical results.

It should be noted that using different play forms within one lesson or using one play form for several days in a row is unpractical since it can reduce the interest of students in the lesson and in study in general. Given that French is studied by students, that is, adults, the following functions are distinguished in the game-based techniques in course of using innovative pedagogical technologies: communicative, entertainment, game-therapeutic, diagnostic, self-fulfilment, and multicultural communication.

Here is an example of using game-based learning techniques. Students are offered a role-playing game. An "applicant" is to pass an interview for admission to the master's program (at French universities, foreign citizens are interviewed). One group of students is "applicants", while the second one is the "Board". "Applicants" are to write a motivational letter about why they want to study at this university and make a CV. Then they are called for an interview (one person at a time). Before the interview begins, the "Board" look through the motivational letters and the CVs of the "applicants". The "Board" discuss questions to be asked to the "applicants". The latter are to use personal data, be ready to answer questions and ask their own questions about studying at the university. At the end, the teacher analyzes the game together with the students and organizes work to correct typical errors.

3.6 Information and Computer Technologies

Information and computer technologies are often used in teaching French. Information training technology is the process of preparing and transmitting information to the trainee, facilitated by computer. Information technologies include programmed learning, intelligent learning, multimedia, simulation learning, and demonstrations [19, 20].

Computer technologies contribute to more effective teaching of foreign languages, the task of which is the interactive component of communication. These technologies have made teaching foreign languages a lively, interesting, creative, and natural process. In addition, teaching a foreign language using a computer has technical advantages. The computer's graphical capabilities make the learning process very visual and allow you to show all types of activities in the form of animation or pictures. This is important, for example, when introducing a new vocabulary, since images on the computer allow you to associate a foreign word or phrase directly with an action, rather than with a phrase or word in your native language. In addition, computer images attract students and create the necessary motivation to learn a foreign language. However, information and computer technologies should be given a limited place in the classroom, since the computer cannot replace human communication, which is required for good language proficiency.

Here is an example of using information and computer technologies in class to prepare for academic mobility. During classes, students watch videos with excerpts of lectures on physics, mathematics, chemistry, etc., which are read by French teachers at universities. Students learn to make notes of these lectures, which is very difficult, because French teachers do not pause to allow students to do this, as it is in Russian universities. At first, students do not manage to take notes of lectures in French, but as they learn, they start understanding the basic principles of note-taking and at the end of training they successfully cope with this task.

Therefore, the use of information and computer technologies significantly increases the effectiveness of teaching a foreign language, because today's students can not live without computers and computer technology.

4 Actual Outcomes

After the students have completed educational programs for preparing to academic mobility and passing the international DELF exam, they successfully undertake master's programs at French universities, study there, and get master's degrees. The French Embassy in Russia offers various types of scholarship programs: for Russian students, to facilitate students' admission to French universities. Over the past six years, 14 KNRTU students have won the Henri Poincaré grant co-funded by the French Embassy in Russia and the government of Tatarstan to study for a master's degree in France. After studying at French universities, the students return to Russia and work in companies using their knowledge, experience, and skills acquired in France.

Students of our university with knowledge of French work part-time in French companies, such as Auchan, Leroy Merlin, Danone, Dekathlon, Renault, etc. On the territory of our region, French companies bring not only French culture, European technologies and create new workplaces, but also set a new pace in staff recruitment. In particular, one of the requirements for the top management is knowledge of French, and it is possible to make a good career in many companies only with continuous improvement of French.

The lessons of French for academic mobility is significant for students of our university. KNRTU signed cooperation agreements in science and education spheres with some higher education institutions of France, for example, with Institut de Recherche de Chimie Paris, Paris-13 University, International fashion school of Mod'Art International of Paris and others. According to these agreements KNRTU and the higher education institutions of France agree to encourage the following activities in particular to promote international academic cooperation: joint programs and meetings for educational and research; joint research in engineering, creation of new technical documentation and production; joint participation in European and Russian grants. Also, Scientific schools, trainings, master classes were carried out on the basis of our university and universities of France due to the mobility and cooperation of KNRTU teachers, students and universities of France.

5 Conclusions

Academic mobility of KNRTU students to French universities contributes to improving the efficiency and quality of education. Many KNRTU students studying French, after receiving a bachelor's degree, continue to study for a master's program in French universities. At our university, French is taught on the basis of the curricula and programs developed specifically for preparing for academic mobility. Teaching French for academic mobility requires a creative approach from the teaching staff, introduction of interactive teaching technologies in the traditional methods, taking into account the purpose, objectives, and the expected results of the class. KNRTU has provided all necessary conditions for students' academic mobility to French universities: the French Language Resource Center is in place, academic mobility preparation programs are being implemented, students participate in grants for studies at French universities and linguistic internships to France, to name just a few. All these academic mobility preparation activities arouse great interest in students. Teaching French for academic mobility requires a creative approach from the teaching staff, introduction of interactive teaching technologies in the traditional methods, taking into account the purpose, objectives, and the expected results of the class. At the same time, considerable attention should be paid to work in an adult audience, where the nature of interactive pedagogical methods of training is completely different in its specificity and step-by-step construction of the educational process.

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Development of the Ability for Professional Interaction in Future Engineers at a Research University

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Abstract. The paper states that the development of the ability for professional communication in a future engineer is a prerequisite for him becoming a skilled specialist, as well as a significant factor in his future professional activity. The solution of production problems and fruitful interdisciplinary team work are facilitated by the communicative and rhetorical qualities of an engineer who is ready for productive business communication and effective presentation of his position, as well as the presentation of work results. The future engineers' professional communication ability should be developed at the university level. We proposed the rationale for its effective development through the creation of a set of relevant pedagogical conditions: the introduction of Rhetoric as an additional discipline or the modernization of the program of an existing subject with a similar focus; the use of specially designed educational techniques and methods for the development of communicative and rhetorical competence; training university staff in the conditions of advanced training; creation by the university of conditions for students' active research and social activities; cooperation of educational institutions with large enterprises, companies and research centers. The paper also provides a pedagogical experiment conducted under the aegis of the Kazan National Research Technological University. We have developed the recommendations for the selection and structuring of the material as well as methods for developing the future engineers' ability to professional communication at a research university; we have also identified problems that require further consideration, including the search for innovative methods.

Keywords: Engineering · Professional interaction · Research university · Future engineers · Pedagogical conditions

1 Context

The high personnel competition caused by modern economic conditions at national and global levels is one of the most pressing problems for university students preparing to join the professional environment. Future engineers must be well-versed in advanced technologies and knowledge of technological equipment, as well as have innovative thinking, managerial, organizational skills, the ability to work effectively in a team; business communication, non-routine task solution skills, the ability to transfer their

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own knowledge and skills (as a teacher or instructor). A university education process must meet the relevant requirements for training. There is a need to strengthen the humanitarian training of engineering students, and in particular, to develop the verbal skills of future engineers, as significant for the effective solution of their professional tasks [1, 2].

2 Purpose

This work aims at identifying and justifying the pedagogical conditions for the development of the communicative and rhetorical competence of engineering university students. An analysis of the specialized literature showed that in the 21st century the engineering and technical duties of an engineer in a modern economy should be inseparable from organizational and managerial activities. It was revealed that the solution to production problems and fruitful interdisciplinary team work is facilitated through the communicative and rhetorical qualities of an engineer who is ready for productive business communication and effective presentation of his position, as well as the presentation of work results [3]. The paper notes that public speaking skills, along with communication skills, are of particular importance for engineers. In engineering, there are a number of responsibilities involving speaking to an audience. This may be a projects defense, making reports at scientific conferences, preparing reports on work done, industrial and organizational speeches. And a special role, bearing in itself social significance, is given to the propaganda function of the profession of engineer. The authors show by the example of a technological research university how to prepare future engineers for professional interaction, what conditions must be created to solve this problem. We also present a training module project with methodological recommendations how to prepare and introduce it in the educational process.

3 Approach

In order to solve the problem of effective formation and development of future engineers' ability to professional interaction, a special study was carried out that facilitated identifying and justifying the need to create a number of pedagogical conditions in the educational institution.

1. Development of an additional Rhetoric training module. It can be included into an existing discipline (for example, the curriculum of the Russian Bachelor's program includes The Russian Language and Culture of Speech) or become an independent discipline, including optional. The module is aimed at active acquisition of practical communication and rhetorical skills.
2. The use of traditional and innovative educational techniques and methods for the development of communicative and rhetorical competence. The need to acquire practical skills in a short time (since humanities are given a small number of hours) determines the selection of productive pedagogical techniques that are focused not

only on the development of relevant knowledge and skills, but on building the students' personal potential as well [4, 11].

Pedagogical technology is a project and its subsequent implementation as a pedagogical activity system, aimed at achieving the goals of education and the students' personal enhancement. Pedagogical technology involves the identification of theoretical and practical approaches to achieve specific results that can be potentially reproducible.

Technology-based education should be innovative, practice-oriented, and conducive to the development of students' personal potential [5, 6]. It involves the use of non-traditional forms of classes, experimental educational techniques, methods, and tools. For the development of students' communicative and rhetorical skills, we need to use active and interactive forms of teaching. In active forms, interaction occurs on the teacher - student basis; it involves discussion, game, training, rating and other methods, as well as master classes. Interactive forms are about student-to-student communication, it involves business games, debates, brainstorming sessions, creating projects, and other methods. Active teaching methods is a system of methods that provide a variety of mental and practical activities of students in the process of acquiring educational material. Active methods contribute to a high degree of students' involvement in the educational process, activate their cognitive and creative activities.

It is important that teaching communication and rhetorical skills should be based on a creative approach on the part of the teacher and reflection (self-esteem, self-control, self-correction) on the part of the students.

3. Adequate university teaching staff training in the context of continuing education. The teacher should be the motivator and coordinator of the students' communicative and rhetorical skills development process. In the 21st century, the development of technology and the availability of any information shifted the emphasis in the role of the teacher in the educational process from transmitting new knowledge to coordinating the process of acquiring this knowledge and motivating students.

   In pedagogical art, not only what the teacher says, but also how he or she presents the material, is extremely important [7, 8]. Ateachershould, infact, beaprofessionalspeaker, fluentin: elocution (this includes voice power, pace and rhythm of speech, intonational diversity and good articulation), compositional techniques (one of the most important principles of successful speech is the correct location of the material), speech purity (the teacher should instill literacy in students by personal example, and this requires strict adherence to lexical, grammar, accentual, and stylistic norms), pedagogical artistry (the teacher's speech and his non-verbal means of communication should create a lively and friendly image).

   Essentially, this pedagogical condition is about the need for appropriate training of university teachers, regardless of the discipline taught by them. [9, 10]. Since in the modern theory and practice of university pedagogy it is no coincidence that the educational function holds a prominent place. The educative process should be aimed at the formation of an all-round personality. This issue is addressed through pedagogical communication between the teacher and students. When the teacher explains the new material, he performs a socially orienting function related to the desire to establish a moral and cultural framework, as well as orient a person in the world of moral values around him.

Pedagogical rhetoric should be understood as competence and become one of the key areas in the process of pedagogical self-improvement, the work that each teacher does to himself [12]. Therefore, the Rhetoric module should be included in the advanced training system, which will be aimed at the systematic development and improvement of oratory skills of the university teacher.

4. Creation of conditions by the university for students' active research and social activities. A practice-oriented approach to teaching should be implemented through both classroom activity and the students' ability to fulfil their potential by participating in the university life [13, 14]. Such practice has a positive impact on communication skills training, formation of public speaking skills in the scientific community, and recognizing them as a significant component of a leader personality. Students learn to defend their scientific interests and show intellectual capabilities. Students should be encouraged to implement their first projects, a system of contests, competitions, intellectual games, volunteering, student tutoring should be developed. The following student activities are recommended to be organized on the basis of the university:

   - conferences and scientific sessions on the basis of the university;
   - providing students with the opportunity to participate in scientific competitions and conferences of regional, federal and global scale;
   - providing the opportunity to receive grants for research and projects;
   - local self-government bodies (trade union organizations) with the possibility to apply for the chairman's position by participating in the elections (by preparing an individual election campaign, respectively);
   - games of skill;
   - student leader contests;
   - tutor support. A system in which student leaders and activists campaign among new students (freshmen and newcomers to the university) to take an active public position at the university;
   - voluntary service organizations;
   - colleges for activists, involving leading teachers and activists among students.

   All these activities are supposed to tune a student to an active professional position, prepare future engineers for competition, and develop important social qualities.

5. Cooperation of educational institutions with large enterprises, companies, and research centers. Communication of students with prominent representatives of the profession contributes to the correct formation of the image of a modern engineer. Vocational training should be close to the scientific and technical activities of future specialists. Science and production integration helps future engineers master the complex ways of professional activity. Barriers should be removed that prevent universities from engaging specialists working in specific enterprises. Equally important is the development of criteria according to which specialists will be invited to the university as mentors and teachers.

   These conditions can be fully created in a research university as an educational institution of a special type. Such a university offers purposeful training of skilled specialists by active research with a focus on the future of graduates, that is, their further functioning in their professional field. The following can be identified among the main features of a research university:

- integrated nature of education. Combining educational, scientific, experimental and production potential. Scientific research is carried out both on the basis of the university and in scientific centers and is practically supported in production conditions.
- the use of modern educational technologies in the training process. They are aimed at solving the university's tasks of education, training and development of qualified specialists and strong creative personalities.
- a developed retraining and advanced training system in place for teachers and other specialists. This system meets the current requirements of the continuing education concept.

A comprehensive implementation of the above conditions on the basis of a best suitable research university will ensure the effective development of the communicative and rhetorical skills of future engineers.

4 Actual Outcomes

The authors have developed a draft program of Rhetoric educational module which is adaptable to specific educational conditions and needs: to become part of general education; to act as an independent discipline in the main program of higher education, to be included in the continuing professional education or teachers' advanced training program. We developed and implemented in the conditions of a technological research university special recommendations for selection and structuring of material, as well as for the methods of developing the ability to professionally communicate with future engineers in a research university.

The objectives of the Rhetoric module: improving the students' communicative and rhetorical skills; formation of self-organization, self-development, and self-evaluation skills; developing effective social interaction, teamwork, and leadership skills.

The module program consists of four sections. The first one, the Canons of Rhetoric: Composition, Speech Culture, Self-Presentation includes four lecture classes (*Traditional Rhetoric and Rhetoric in Professional Activities; Canons of Traditional Rhetoric. The Doctrine of Composition; the Culture of Human Speech in the Context of his Social and Professional Activities; the Speaker's Self-Presentation*) and four practical classes (*Compositional y of Public Speaking, Forecasting and Monitoring of Communicative Situations, Planning of Public Speech, Conscious Use of Non-Verbal Means of Communication*). The second one, Communication Speech Quality, is presented with lectures (*Communication as a Social and Professional Phenomenon, Communication Speech Qualities*) and practical classes (*Speaker's Communication Speech Quality Analysis, Practical Application of Communicative Skills in a Debate*). The third section, Development and Improvement of Speech Skills includes a theoretical class and practical ones (*Speaker's Speech Skills, Training in Speech Techniques* *according to the Stanislavsky System*). The final, fourth section is Ethics of Professional Communication.

The final test paper is the preparation of a message on a given topic (an independent analysis of a proposed excerpt) followed by the presentation to the audience. The work for the presentation should include all the studied aspects of rhetorical mastery. It should correspond to the basic laws of public speech, and it should also implement the communicative and rhetorical scenarios developed during practical exercises. The presentation itself must comply with the requirements of high-quality public speech, therefore, students should take into account the use of verbal and paralinguistic techniques.

Therefore, the theoretical part was based on the provisions of traditional rhetoric. In practical studies, students were focused on creating their own texts and speaking to the audience as speechmakers. Various active and interactive forms were used: discussion, game, training and other methods, master classes, debates, brainstorming, etc. While teaching, we revealed the efficiency of the case-study and the script methods in the development of speech-cognitive, communicative, and rhetorical abilities of students. We justified the use of non-traditional methods, techniques and tools borrowed from related sciences and other cultural and social fields (psychology, philology, various fields of art, physical education, etc.).

To identify the pedagogical effectiveness of the presented Rhetoric project, we organized and carried out a pedagogical experiment among bachelor students receiving higher and extended education in KNRTU. At the ascertaining experiment stage, we conducted a survey aiming to identify: the students' response to various communicative and rhetorical situations, speech problems, the level of the students' awareness of the significance of their communicative and rhetorical qualities, the need for studying rhetoric.

The survey input allow us to conclude that the speech skills of engineering students, reflecting a certain manner of behavior in various communicative-rhetorical situations, are not sufficiently developed. For example, in a dispute, only 42% of respondents are ready to defend their point of view to the end, the rest are inferior in the dispute and are not even initially ready to defend their opinion, refusing to engage in controversy. This situation is also an indicator of insufficient development of emotional control skills in stressful communication. 23.5% of respondents admit that they would get to the conflict and fight. The situation of insecurity in one's communicative and speech qualities is naturally observed in a high level of excitement among the majority of respondents in situations like a business meeting, public speaking, communication with strangers. Thus, almost 90% of respondents feel nervous while in expectation of a business meeting. More than 3/4 of the students surveyed experience glossophobia and 21% of them tend to feel sense of apprehension of high intensity. And almost half the students surveyed do not feel comfortable communicating with strangers, and some of them try to completely avoid contact with people they don't know. The lack of significant development of mental and speech skills is expressed in a situation of communicative impromptu, when communication is unplanned and sudden. The desire to be prepared in advance for a speech situation is clearly illustrated by the fact that 50% of respondents find it more comfortable to express their point of view in writing, while only 27% gave preference to the oral form.

The survey results allow us to conclude that the respondents have emotional and psychological blocks that affect the quality of their communicative and rhetorical capabilities. An example of such blocks is the prejudice about the existing problem in communication between representatives of different generations. Thus, 55% of students surveyed are confident in the difficulties of communication of people of different ages. Emotional psychological blocks in communicative speech situations also include the expression of excitement factors in the respondents' speech behavior. 65% of the students surveyed tend to physically manifest their excitement which is reflected in their ability to reproduce and control speech.

An important characteristic of the opinion of the students surveyed is a conscious perception of the communicative and rhetorical potential. This is reflected in an objective critical assessment of the state of communicative culture in the context of the modern social media environment. Most of the students surveyed note a tendency to move communication into the virtual space of social networks, and to minimize live communication through gadget culture.

94% of the respondents, being future engineers, recognize the importance of communicative and rhetorical competence in their future professional activities. And 98% consider it necessary to develop their communication and public speaking skills.

Along with the survey, part of the experimental group was subject to pedagogical observation aimed to identify the level of rhetorical skills and sociability of students, as well as determine the main indicators of rhetorical skills that will become control points of our experiment. In parallel with the pedagogical observation, a written test was conducted for students in order to more objectively identify knowledge of the norms of the Russian language, which included tasks to check accentological, grammatical, and stylistic norms of the language.

The totality of the results of all parts of the ascertaining experiment allowed us to make the following conclusions:

- The vast majority of technical students feel handicapped in various communicative situations due to the lack of appropriate skills.
- Basically, future engineers have a low rhetorical skills level, experience difficulty in compiling and representing socio-journalistic and professional texts.
- The level of speech culture of engineering university students is satisfactory, but is not adequately demonstrated verbally.
- Most students of these specialties feel nervous and even fear public speech and spontaneous communication situations.
- The vast majority of future engineers recognize the importance of communicative and rhetorical skills in their upcoming professional activities.
- Students participating in the experiment were able to critically assess the level of development of their own communicative and rhetorical skills and understood the need, as well as expressed a desire to improvement these skills.

As part of Rhetoric educational module, we have developed and conducted a training experiment, which was based on the concept of the development of future engineers' communicative and rhetorical competence. Based on the ascertaining experiment, we have determined the abilities and skills to be assessed at the end of the training experiment.

Experimental training was carried out in several areas:

1. Theoretical material study: assimilation of the basic concepts and terms of rhetoric, phenomena, factors, laws, and rules.
2. Practical rhetoric means study: laws, types of speech, styles, tropes, verbal and non-verbal expressive means.
3. Modeling of communicative-rhetorical situations based on the case-study and script methods. The case-study method is a modern technology of professionally oriented training. The method is a problem situational analysis, refers to non-game imitation active teaching methods. The case-study method is based on the joint effort of a group of students to analyze a situation - case (in our case, a communicative rhetorical situation) [15, 16]. The result of this work is finding a practical solution by evaluating the algorithms found and choosing the best one in the context of the problem at hand.
   The specific feature of the application of the case method as part of practical training in rhetoric is that often the result of elaborating situations is not a specific algorithm of actions, but a ready-made speech scenario [17]. In this regard, we used a script method that is actively practiced in management. A script is a ready speech scenario for working out a specific task or situation. A set of well-developed cases and scripts ready for them can serve as a kind of meccano for a novice speaker. This practice is intended to help students prepare presentations as part of the module program, as well as in their further educational and professional activities: speaking at seminars, scientific conferences, defending term papers and dissertations, projects, etc.
   The method of cases and ready-made scripts, in our opinion, is most effective among representatives of technical specialties (engineers). Since such a technique, in fact, represents the principle of formulas familiar to them, where there is a ready made template and they only need to substitute variational values depending on problem data and situations. It is important to note: despite the fact that the result of the work simplifies, and even, at first glimpse, primitivizes the student's activities as a speaker (in the sense of working according to a pattern), the process of finding solutions and considering various possible options for events is an active creative activity aimed at verbal and cogitative development. In the case study method, the formality of the traditional material presentation by the teacher is replaced by the conditions of creative competition and emotions associated with the heuristic side of the process.
4. Creation by students of their own texts based on the use of studied and practiced material.
5. Students' speech as professional speakers using the studied rhetorical means.
6. Students' organized participation in the simulation of disputes and other speech situations of professionally oriented business communication.
7. Students' practice in assessment and self-assessment in the field of communicative and rhetorical activity.
8. Training of students' practical speech-pronunciation skills by performing breathing, diction development, facial muscle control, intonation variability exercises based on the scenic speech technique system.
   A training experiment confirmed the effectiveness of the proposed methods. The test analysis allowed us to conclude that the determined indicators of the engineering

students' rhetorical skills, according to the results of experimental training, have positive dynamics. We have analyzed the following indicators of the rhetorical skills of future engineers:

- Proper structuring of text composition;
- Building an argumentation system based on the laws of logic;
- Compliance with grammatical, accentological, and stylistic norms of the Russian language;
- Showing a rich vocabulary;
- Use of means of image expressions;
- Conscious possession of prosodic means of expression;
- Conscious use of kinesic (non-verbal) means of expression;
- Control of traces of emotion;
- Ability to answer various types of questions.

For each of the indicators, obvious progress was observed. This conclusion was made by comparing the percentage of the total number of people of the two test groups that correspond to the indicators at the time of the ascertaining experiment and the percentage of students who meet the specified criteria at the final stage of the training experiment.

Thus, the effectiveness of our draft program of the Rhetoric module was proved by the results of an experimental study. Based on this, we have developed a number of recommendations for material selection and structuring as well as methods for developing the communicative-rhetorical competence of future engineers:

1. The theoretical part of training should be based on the provisions of traditional rhetoric, which can give a complete picture of the preparation and implementation of public speech in a modern developed information-oriented society and correspond to the function of mastering all types of social and speech interaction.
2. The effective development of communication and rhetorical skills is determined by the practice-oriented nature of training. The emphasis should be placed on creating by students of their own texts and speeches in front of an audience as a speaker based on the use of the studied and practiced material.
3. In training, it is recommended to use both active and interactive forms: discussion, game, training and other methods, master classes, debates, brainstorming, etc.
4. It is recommended to use the capabilities of innovative educational techniques and methods. Thus, for example, we have revealed the productivity of the case study and the script method in relation to the development of speech-cognitive, communicative, and rhetorical abilities of students.
5. It is recommended to search for non-traditional methods, techniques and means borrowed from related sciences and other cultural and social fields (psychology, philology, various areas of art, physical education and others). Such examples were shown in our draft module program: methods used in scene speech training - various exercises with voice intonation, elocution, etc., an exercise to develop breathing technique, borrowed from the vocal methodology, training the respiratory and facial muscles based on the methods of physical culture, etc.

5 Conclusions

The ability to professional communication with future engineers should be developed at the university level. We proposed the rationale for its effective development by creating a set of appropriate pedagogical conditions. These conditions take into account and rely on the capabilities of a research university. We have also developed recommendations on selection and structuring of material and methods for a special training module. In course of the research and the analysis of its results, a number of problems were identified that require further consideration, including a more extensive search for innovative methods of motivational support and the development of future engineers' professional communication skills.

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Poster: Development of Managerial Skills in Engineering University Students in the Context of Modern Industrial Revolutions

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Abstract. The paper theoretically substantiates the need for managerial skills development in engineering students. The paper is focused on the basic traits necessary for the successful formation of managerial skills in engineering students, the impact of gender and "emotional quotient" (EQ) on leadership style, and the development of "hard" and "soft" skills. For a manager, there are no absolutely bad or good personal qualities, but their totality is a manageable resource. The gender factor here has a significant impact on management style and quality. Training programs based on students' personal characteristics and specific needs, a combination of coaching, training and individual classes guarantee the required level of managerial knowledge and skills. The emphasis is on the fact that training technologies and coaching methods are effective for the formation and development of managerial skills among students of engineering specialties. The authors believe that under current conditions, a greater emphasis in management practice should be placed on innovative principles and methods related to the formation and development of neuroplasticity, Neuro Science, EQ, etc. in engineering students.

Keywords: Management · Engineering manager · Coaching · Training · Emotional quotient (EQ) · Hard skills · Soft skills · Gender specificity of leadership style · Development of managerial skills

1 Context

Hard work and readiness for continuous professional improvement is the prerequisite for achieving high results in the context of modern industrial revolutions and are vital for ensuring high managerial qualification in a future engineer. Training programs based on students' personal characteristics and specific needs, a combination of coaching, training and individual classes guarantee the required level of managerial knowledge and skills.

Awareness of all your personal character traits makes it possible to manage them in cases where there is a need for managerial decisions in which rash actions can lead to

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negative consequences. Through objective self-evaluation and self-development, a future manager gets the opportunity to increase the efficiency of company management.

Taking into account all modern trends in theoretical scientific constructs and in actual business practice, the authors believe that modern managers, in addition to professional engineering competencies, should also have special managerial skills that ensure the successful functioning of the company, achievement of goals, a competitive edge in production, and personnel management efficiency. Managerial skills are formed and developed using special techniques.

2 Purpose

The paper theoretically substantiates the need for managerial skills development in engineering students. The paper is focused on the basic traits necessary for the successful formation of managerial skills in engineering students, the impact of gender and "emotional quotient" (EQ) on leadership style, and the development of "hard" and "soft" skills.

3 Approach

Classics of management theory P.F. Drucker, M.H. Meskon, M. Albert, F. Khedouri believe that management is a special kind of activity consisting of planning, organization, motivation and control, necessary in order to turn an unorganized crowd into an effective focused and productive group, as well as formulate and achieve company goals [1, 2].

In 1923, M. Weber in "Economics and Society: the Foundations of Explaining Sociology" described the "ideal type" of a manager with the following characteristics:

- persons in governing bodies are personally free and act only within the framework of "impersonal" duties existing in this company;
- involves a pronounced hierarchy of roles and positions;
- there is a pronounced specification in place of each of the managerial roles and positions functions, while the competence of individuals in each position on a narrow range of problems is assumed;
- individuals are hired and continue to work on a contract basis;
- people in positions are paid a salary depending on their hierarchy level in the company;
- bureaucracy is a career structure in which employees are promoted according to their merit or seniority, regardless of the manager's opinion;
- the position held by the individual in the company is considered by him as the only or, at least, the main job;
- the activities of bureaucracy representatives are based strictly on internal code of conduct and are subject to control [3, 4].

According to M. Weber, this "ideal type" of company management is based on one all-encompassing phenomenon – strict rationalization. However, such an ideal situation does not exist in reality, moreover, in reality, often replacing some goals with others, this type of control begins to slow down progressive processes [5, 6]. Therefore, the concept of M. Weber was criticized by other researchers, such as R. Merton, P. Blau, M. Crozier, R. Mills, etc.

So, for example, American sociologist A. Gouldner argued that a modern manager should combine three functions that are incompatible in one person:

1) Making decisions about the future of the company, which requires powerful intelligence.
2) Analysis of the conditions, resources and possibilities for implementing decisions. Which requires competence.
3) Control over the implementation of decisions, which requires strong will [7, 8].

Since a modern manager is an ordinary person, he cannot perform all the functions assigned to him. Therefore, A. Gouldner believed that managing a company should involve separation of functions between competent specialists, and responsible decisions should be taken by experts [9].

In order to provide the balance of necessary soft skills in a future engineering manager, psychological capabilities should be engaged that give the synergistic effect of the interaction of several psychological characteristics.

This opportunity is provided by emotion intelligence.

Today, this concept is a real sensation. After the publication in Daniel Goleman's book of data that only 15% of a leader's success is due to his mental stature (IQ), and emotional intelligence (EQ) accounts for 85%, the concept of emotional intelligence began to gain rapid popularity [10, 11].

It is important to realize that in this case we are not talking about the dominant role of the intelligence, but rather about the interpenetration and interaction of cognitive and emotional processes, about the "unity of affect and intelligence", as wrote the outstanding psychologist Lev Vygotsky.

By the time Goleman's concept of emotional intelligence appeared, a number of scientific papers had confirmed that emotionality affects intellectual and logical activity, and therefore, the efficiency of production and management processes. Among the most important of them are the works of Antonio Damasio and Daniel Kahneman. Damasio's neurophysiological studies showed that a person who, due to various injuries, has lost the capability to emotions, ceases to be successful, because he can no longer make decisions. And the decision-making process is fundamental in the process of managerial activity. And in 2002, psychologist Kahneman proved that economic decision making is influenced by irrational factors, in particular emotions, (for example, feeling fear, a person overestimates the magnitude of possible losses) [12, 13].

We adhere to the concept of these scientists and believe that the emotional competence of a future manager involves the possession of four types of skills: awareness of one's emotions, awareness of other people's emotions, management of one's emotions, management of other people's emotions.

In view of all the modern trends in theoretical constructs and in actual business practice, the authors believe that today's managers, in addition to professional engineering competencies, should have special skills that ensure the company's successful performance, achieving goals, competitiveness in production, and efficiency in staff management. Managerial skills can be formed and developed using special techniques.

The current sociocultural situation is characterized by cardinal transformations in gender relations. At present, gender dispositions are changing radically, not only in family relations, but in fact in all areas of public life – production, labor, education, culture, services, etc. The deepest transformation of gender roles is determined by a wide range of social causes, one of which is the large-scale feminization and emancipation processes [14, 15].

For example, at the moment, in the contingent of technological universities students in the Russian Federation, the share of women is about 40%, and in some engineering specialties, the percentage of women exceeds the male students [16, 17]. Today, women increasingly prefer traditionally men's occupations, sometimes taking leading positions in them. This is especially evident in the field of management.

The widespread gender drift processes in the occupational sphere cannot but be taken into account by the system of higher technological education, which, along with the formation of professional competencies, the need due to the current situation, pays increasing attention to the training of engineers with managerial skills.

In this regard, it should be noted that in the early 80s of the 20th century, American researcher Roger Sperry won the Nobel Prize in cerebrophysiology, proving the functional asymmetry of the left and right hemispheres [18, 19]. From that moment on, the emotional and volitional behavioral features of men and women were scientifically justified and their study was continued as part of gender issues - differential and gender psychologies appeared, which objectively study the behavior of men and women. The relevance of such studies is beyond doubt. On the contrary, they are actively used in training specialists for various types of professional activities in accordance with the gender context.

In the current sociocultural situation, there is a demand for certain leadership skills, some of which have a natural genetic predisposition in men, and others in women. Men and women differ significantly in neuro-psycho-physiological parameters. There are some prerequisites for leadership in women, allowing them, for example, to be successful leaders:

1. A predisposition to choose a networking strategy. It is a focus on joining efforts together, not on competition. The choice of interaction strategy was described by S. Covey in The 7 Habits of Highly Effective People - actions in the win-win style - a general philosophy of interaction between people, aimed at the constant search for mutual benefits. The ability to build a team interaction culture gives an undeniable competitive edge. As a result, the overall efforts are concentrated on the market struggle, without energy losses for demotivating competition within the team.
   A manager is capable of building a highly effective cooperation culture when his own paradigm of actions is based on the win-win paradigm. In women, this quality is determined by their social nature, they act as the guardians of the hearth and try to rally the team as much as possible, choosing a partner management style.
   In men, this leadership quality is not congenital and requires development. Men have the spirit of competition in the genes, they always compete, including within

the team: physiologically, intellectually, socially, that is, they are guided by the win-lose paradigm.

2. A predisposition to share success with the entire team, and not ascribe it to personal merits. Women, first of all, demonstrate team merit and are rather modest in praising their own merits. In general, women are empathetic, able to feel the nuances of relationships between people, and show sincere concern for each member of the team, i.e. they have a more developed emotional intelligence (EQ). EQ helps recognize feelings, both ours and other people's; and at the same time control behavior and build communication taking into account these feelings. With a low emotional intelligence, it is difficult to work in a team and lead people. Without it, a manager is not able to put himself in an employee's shoes to better understand, agree, share experiences, and forgive.

   Men, in most cases, take credit for success; individualism, as a personality trait, often dominates their behavior.

   Therefore, as part of vocational training, the system of higher technological engineering education should not only take into account the specifics of gender characteristics, but also actively apply new methods and training forms aimed at developing and maximizing practical application in the future profession that gives a wide opportunities for the realization of the originality of gender differences defined by nature itself.

4 Actual Outcomes

Note that there are many methods for managerial skills formation and development. However, we should first realize that a person's character is not constant, and the key to formation and development of managerial skills is in the actions through which a manager shows himself. Therefore, the authors believe that training and coaching techniques are the most effective tools.

Training is a unique technique that allows you to achieve your goals within the optimal time. That is, well-planned training is the best method for achieving educational goals in terms of the ratio of the costs invested and the results achieved.

The coaching method is designed to expand the capabilities of engineering managers who are aware of the need for change and have set the task of their own professional and personal growth. It can be aimed at implementing plans in various areas of life: business, career, education, interpersonal relationships.

As a developing practice, coaching is based on the idea of joint continuous development of the environment and the potential of coaching participants [20, 21]. Coaching is sustainable since the philosophy of this system of methods was originally based on the recognition of the interests of those around you. Coaches see each person's untapped capacity and the possibility for its joint development.

Coaching is a step-by-step system of methods for organizing a living space in which a subject acts together with others, actively creating the world and introducing his individuality into it. It is organized in such a way that it changes the environment in which the coach is, and people in this environment. This results in the development of the coaching bond of the coaching partner and the environment in which they interact.

In this regard, coaching as a system of interaction with the environment in the process of production activity helps to make the environment effective and helping. This saves effort to resolve inefficient communications and makes managerial actions integrated and synergistic.

And it is not professional competencies, that are dominant in management, the so-called "hard" skills, but "soft" skills derived from a manager's personal skills and habits.

5 Conclusions

The authors believe that under current conditions, a greater emphasis in management practice should be placed on innovative principles and methods related to the formation and development of neuroplasticity, Neuro Science, EQ, etc. in engineering students.

Therefore, the part of emotional intelligence that is responsible for understanding others can be trained using simple exercises. The authors suggest using effective methods in preparing future engineers. These include emotional competence development trainings, individual coach consultations and self-development, that is, individual work to develop skills, requesting constructive feedback from others.

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The Blended Teaching and Learning Methods and the Implementation of Online Laboratories in Electrical and Computer Engineering Education Programs

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Abstract. This article describes the Blended Teaching and Learning methodologies and the pedagogical approaches that use Information and Communication Technologies in the field of Electrical and Computers Engineering (ECE) Education Programs. The paper also reflects the collaboration in the field of Online Engineering between the Technical University "Gh. Asachi" from Iasi, Romania and Menoufia University, Egypt, in the context of the Erasmus Plus Program of the European Union. In this paper, we have reviewed the recent documents of: European Society for Engineering Education, International Society for Engineering Education, Institution of Electrical and Electronics Engineers, International Association of Online Engineering, and American Society for Engineering Education to identify the specific pedagogical characteristics used in the computerized training process. The integration of online laboratories in the engineering training process, the use of Virtual Learning Environments, the inclusion of Open Educational Resources are the strategies used in this project. The impact of using Massive Open Online Courses in Education Programs is also analyzed. The cooperation between our universities began in 2017 and have result in the publication of a number of articles in International Conferences Proceedings in 2018 and 2019: International Conference on Virtual Learning, eLearning and Software for Education, International Conference on Electromechanical and Energy Systems. Between August 1, 2020 and July 31, 2021, an exchange of teachers and students will take place within an Erasmus Plus Action.

Keywords: Blended Teaching and Learning · Virtual and remote laboratories · Open Educational Resources · Electrical and computers engineering education programs · Virtual Learning Environments

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1 Introduction

The paper reflects the collaboration in the field of Online Engineering between the Faculty of Engineering, the Menoufia University, Egypt, and the Faculty of Electrical Engineering, the Technical University "Gh. Asachi" from Iasi, Romania and in the context of the Erasmus Plus Program of the European Union.

This article describes the Blended Teaching and Learning (BTL) methodologies and the pedagogical approaches that use Information and Communication Technologies (ICT) in the Electrical and Computers Engineering (ECE) Education Programs. In this paper, we have reviewed the recent and programmatic documents of: the European Society for Engineering Education (SEFI), the International Society for Engineering Education (IGIP), the Institution of Electrical and Electronics Engineers (IEEE), the International Association of Online Engineering (IAOE), and the American Society for Engineering Education (ASEE) to identify the specific pedagogical characteristics used in the BTL process.

The cooperation between our universities began in 2017 and have result in the publication of a number of articles [1–6] in Intl. Conf. Proceedings (ISI Thomson indexed) in 2018 and 2019: the Intl. Conf. on Virtual Learning (ICVL), the Intl. Conf. eLearning and Software for Education (eLSE), the Intl. Conf. on Electromechanical and Energy Systems (SIELMEN)-also IEEE indexed. Between Aug. 1, 2020 and July 31, 2021, an exchange of teachers and students will take place within an Erasmus Plus Action.

Both Students and Professors will use the BTL Methods in Iași, and Menoufia. The integration of online laboratories (both Virtual and Remote) in the engineering training process, the use of Virtual Learning Environments (VLE), the inclusion of Open Educational Resources (OER) are the strategies used in this project. The impact of using Massive Open Online Courses (MOOC) in ECE Education Programs is also analyzed.

2 Engineering Education in IGIP and SEFI Vision

Engineering education is the activity of teaching knowledge and principles to the professional practice of engineering.

Some of the aims of the International Society for Engineering Education (IGIP) [9–11] and European Society for Engineering Education (SEFI) [12] are to:

- improve teaching methods in technical subjects;
- develop practice-oriented curricula that correspond to the needs of students and employers;
- encourage the use of new media in technical teaching;
- integrating languages and the humanities in engineering education;
- support the development of engineering education in developing countries.

The following didactical and organizational principles were formulated as guiding principles for Curriculum Engineering Education Model:

A steady workload is better than learning to absorb an overload of information for tests;
Frequent and adequate feedback helps students adjust learning;
A variety in teaching methods keeps students engaged;
Community helps students help each other;
Ambitions must be clear and high, yet realistic; and
Teachers work best in teams, with minimal regulation.

3 Preparing STEM Teachers and Students to Use Blended Teaching and Learning Environments

The preparation of teachers Science, Technology, Engineering and Mathematics (STEM) Teachers and Students to use blended and online teaching should contain specific chapters/modules that will be reviewed in the paper. These modules can be completed either sequentially in the order presented, or they can also be viewed as stand-alone resources [13–16].

For example, International Engineering Educator ING.PAED.IGIP Curriculum includes a module named Fundamental principles of educational technology, where ICT, media and e-learning are discussed. Technical devices, equipment and systems used to support instruction, the operation of these media and e-learning, their sensible use and integration into the instructional process are the main problems dealt with in this unit.

3.1 Instructional Design Models and Theories of Learning Module

The module *Instructional Design Models and Theories of Learning* presents Learning theories (from behaviorism, cognitivism, constructivism and connectivism) identified in relation to common instructional design models such as: ADDIE (Analysis, Design, Development, Implementation, Evaluation); Gagne's Nine Events of Instruction (Gain attention; Inform learners of objectives; Stimulate recall of prior learning; Present the content; Provide "learning guidance"; Elicit performance/practice; Provide feedback; Assess performance; Enhance retention and transfer to the job); ARCS (Attention, Relevance, Confidence, Satisfaction) and Backward Design (Identify the results desired/big ideas and skills; Determine acceptable levels of evidence that support that the desired results have occurred/culminating assessment tasks; Design activities that will make desired results happen/learning events).

3.2 Online Course Development

The *Online Course Development* module analyses following subjects: Planning to Teach Online [The Importance of Planning; Process of Online Course Development (Institutional Procedures and Resources; Instructional Design Team Members' Roles); Lesson Plan/storyboard (Purpose; Main Elements)]; Designing blended engineering courses using CDIO (Conceive–Design–Implement—Operate) Approach [7, 8].

Typical BTL Engineering Course components are:

Online Components are:

- Educational Materials & Assessments: Lecture Notes; Lecture Presentations; Additional Reading Materials; Virtual Laboratories (Labs); Assignments; Online Quizzes & Tests; Video/Audio Clips of material; Video Conference material; Webcasted Lecture;
- Educational Support: Announcements of course-related matters; E-mail; Discussions Groups; Student faculty interaction;
- Course Management: Course registration and

Face-to-Face (F2F) Components:

- Educational Materials & Assessments: Lab Sessions; Supplemental Tutorial Sessions (if needed); Project implementations; Semester-end Examinations; Workshop Component of a Course (if any)
- Educational Support: Physical meeting with advisers

The participants of this module should be able to: Explain the importance of the course planning process; Explain the stages in online course development; Identify roles and responsibilities of different team members in online course development; Develop a lesson plan (storyboard) for one module (week, unit) of their future online course.

3.3 Online Teaching Skills

The module *Online Teaching Skills* has following Agenda (Topics and Subtopics): Teaching online vs. teaching face-to-face (similarities and differences); Online teaching skills (Pedagogical; Technical; Administrative); Self-assessment activity.

Pedagogical Techniques for BTL in Engineering Education are:

Most Used Pedagogical Techniques: Group problem-solving and collaborative tasks; Problem-based learning; Discussion; Case-based strategies; Simulations or role play; Student-generated content; Coaching or mentoring; Guided learning; Exploratory or discovery; Lecturing or teacher-directed activities; Modeling of the solution process.

Future Pedagogical Techniques: Authentic cases and scenario learning; Simulations or gaming; Virtual team collaboration; Problem-based learning; Coaching or mentoring; Guided learning; Self-paced learning; Exploration or discovery; Modeling of the solution process; Discussion; Debates and role play; Lecturing or instructor-directed activities; *Socratic* questioning.

3.4 Learning Outcomes as Master Plan for Design

Another important module, *Learning Outcomes as Master Plan for Design,* introduces the role of learning outcomes in online, face-to-face and blended course design. During this module blended teachers will use Bloom's Taxonomy of Educational Objectives to develop clear learning outcomes for an online or blended course or module. They will also evaluate students learning outcomes to make sure they are specific, measurable, attainable, and relevant and timed appropriately for the length of your course or module.

Topics include: Introduction to Course Design Cycle: Constructive Alignment (Learners construct meaning from what they do to learn. The teacher makes a deliberate alignment between the planned learning activities and the learning outcomes.)

Writing Learning Outcomes are: Learning Outcomes have three main components: an action word that identifies the performance to be demonstrated; a learning statement that specifies what learning will be demonstrated in the performance; a broad statement of the criterion or standard for acceptable performance.

Bloom's Taxonomy of Educational Objectives (guide to choosing action words): Affective, Cognitive, and Psychomotor domains; Action Words for Learning Domains.

Evaluating Learning Outcomes: **SMART** outcomes: **S**pecific skills/value/knowledge; **M**easurable and/or demonstrable; **A**ttainable by students at current level; **R**elevant for students, course, program, degree; **T**imed appropriately for module or course length.

Evaluating Achievement of Learning Outcomes: Assessment Strategies.

3.5 Assessment in Online Environments

The module *Assessment in Online Environments* introduces strategies for planning assessments, grading student work and providing effective feedback in online learning environments.

Topics: Place and Purpose of Assessment: Assessment in Constructive Alignment; Formative and Summative Assessment; Assessment Tools and Activities; Effective Feedback through Grading Rubrics: Characteristics of Effective Feedback; Grading Rubrics.

3.6 Communication Strategies in Online Environments

Communication Strategies in Online Environments module introduces teachers to tools and strategies that can help them communicate effectively with students in the online environment. They will review how you can apply the Community of Inquiry model to increase cognitive, social and teaching presence, as well as tips and techniques for planning and moderating effective online discussions. In this module, teachers will design a communicative learning activity to increase interactivity in the online environment.

Topics and Subtopics are: Online Courses as "Communities of Inquiry": What is Community of Inquiry; Cognitive, Social & Teaching Presence; Types of Asynchronous Communication: Meaningful Online Discussion; Discussion Board/Forum Facilitation; Types of Synchronous Communication: When to Use Synchronous Communication; Preparing for a Synchronous Session.

3.7 Synchronous and Asynchronous Technological Tools

An important module introduces *Synchronous and Asynchronous technological Tools* for online learning activities and communication. In this module, teachers will be expected to apply one synchronous and one asynchronous tool in the design of an online or blended course or module. Educational technologies such as discussion boards, web-conferencing, blogs, wikis and social media will also be evaluated.

By the end of this module, participants should be able to: Evaluate a variety of educational technologies on the basis of hands-on experience, including experience with LCMS (Learning and Content Management Systems), email, discussion boards, blogs, ePortfolio, wikis, social media, text chat, and web-conferencing.

3.8 Online Learning Communities

The module *Online Learning Communities* introduces strategies for building a sense of community among online learners and activities based in social learning theory to ensure successful educational experiences. In this module, you will compare methods for developing online social presence and identify strategies and activities for developing and maintaining supportive online communities.

Topics and Subtopics are: Defining Online Learning Communities: Function; Identity; Participation; Interaction; Online Learning Communities and Online Classes/Collaboration: Online Spaces; Learner/Peer Feedback; Group Assignments; Strategies to Develop Successful Online Learning Communities: Modeling; Articulation; Coaching; Exploration; Reflection; Scaffolding.

Coaching is a form of development in which a person called a coach supports a learner or client in achieving a specific personal or professional goal by providing training and guidance.

4 Virtual Learning Environment MOODLE

MOODLE (moodle.org; moodle.com) is a tool which enables you to create a website environment for BTL class with online activities such as forums and quizzes.

Virtual Learning Environment (VLE), as Moodle, is easy, free, and relatively safe to use:

- The Moodle website can be set up to allow only your students to enter it and explore it.
- It is a controlled environment for your students to use the internet.
- Because it's free, many educational institutions use it.
- This can allow you to share content and ideas with other teachers easily.

5 BTL Course Components and Activities for Electrical and Computer Engineering Education

Course content in a VLE as Moodle is aligned with curriculum standards, objectives, assignments, assessments.

Course Syllabus contains: prerequisites; objectives; assignments; test schedule; required materials; grading criteria; testing information; library resources; any on-campus requirements; work ethics information. Staff Information includes instructors' names. The course contains Student Information and orientation and explains: how to get started; technical equipment requirements; technology competency requirements; browser recommendations; drop deadlines; format for assignments; requirements for chat room and/or e-mail; instructor response time; troubleshooting advice.

Course Calendar–Due dates for readings, activities, assignments, quizzes, and exams. Course Assignments and Activities are designed to be interactive and requires students to interact with: each other and their instructor via e-mail, chat room, and/or discussion board; and to address a variety of learning styles through: written assignments; reading activities; discussions; simulations; case studies; and give students the opportunity to engage in critical and abstract thinking. Students are challenged to complete one or more of the following: solve problems; apply concepts in context; complete practical applications.

Course Documents–Course content is delivered through media such as: PowerPoint presentations; Short lectures in audio or video format; links to resources on websites; CD-ROM/online materials. Lectures–Notes and audio to highlight key concepts of course content. Communication Tools include: areas for sending and receiving e-mail, participating in group or class discussions about particular issues, keeping electronic journals, completing "simulated lab" exercises to prepare for "real lab" experiences, or engaging in chat sessions. Many students are able and willing to participate more fully online than in face-to-face classes, especially when discussion assignments require each student to post a comment or the results of a brief assignment and to reply to a comment or question from other students. Student Tools–to send and receive completed papers, homepages, and access to grades.

Assessment Tools–Areas for quizzes, exams, and surveys; online grade books; and assessment statistics. Course assignments are designed to be interactive and require students to interact with: each other and their instructor via e-mail, chat room, and/or discussion board. Assessments include a variety of the following: online or proctored testing; standardized tests; projects; demonstrations; presentations; case studies.

6 Online Laboratories in Engineering Education

The role of laboratory experiments is to develop the critical thinking of students working with real or virtual experimental resources [17–19].

Students need to understand what kind of results they collect and analyze for each experiment. The student must be able to not only perform the correct experiment, but also to interpret the results correctly.

Online laboratories are fundamental to the experiments carried out by students during the individual study. In the case of virtual laboratories operated from a distance, students studying engineering can develop their experimental skills and become familiar with the real phenomena.

Software simulations that use the web are called “Virtual Labs” and use only software. “Remote laboratories” consist of real measuring equipment and devices and allow students to use real-world hardware through software.

ABET (Accreditation Council for Engineering and Technology) requires students studying engineering to obtain “the ability to design and conduct experiments” and “the ability to use modern engineering techniques, skills and tools.”

The EUR-ACE (European Accredited Engineer) criteria require that students have: “The ability to select and use equipment, tools and methods appropriate to a field of activity”, as well as “An understanding of the techniques and methods applicable to a particular technical area/technological knowledge and knowledge of their limitations”.

Many engineering study programs now incorporate remote (and/or virtual) laboratories either to reduce costs; either for the shared use by several institutions of the equipment; either for pedagogical reasons. The advantages of remote (and/or virtual) laboratories include: students’ access to equipment; greater flexibility in the programming of laboratory experiments; a wider range of tasks or activities possible; increased opportunities for collaboration between students. In the case of laboratories accessed online, students can learn anytime and from anywhere they have Internet access. As in the case of real experiments, students can collaborate in the case of online laboratories.

By considering the future engineer as a teamwork member, with geographically dispersed fellows, students practice communication. We will present the concept of conducting a virtual experiment (the didactic scenario of a virtual experiment, or at a distance). First the student will have to read an introductory teaching material that presents the subject/topic, the purpose, objective and theory behind the experiment and to understand the applications of the phenomenon in various technological fields.

The student will then take an online test to assess their level of knowledge and understanding of the stages of the experiment (procedure, prerequisites, hardware and software details for each stage of the experiment, the procedural details of how to use the remote control panel effectively).

The student will follow with the help of simulations and video sequences the exemplification of theoretical concepts in order to deepen and understand the concepts better. There will be followed by a questionnaire with questions to which the student will receive additional information. Using the remote control panel the student will perform the experiment, visualizing and analyzing the experimental results. In this way students will understand and learn what the procedures for correcting unwanted evolutions of the experiment are. To further deepen the cognitive understanding, each student will receive additional tasks and will be evaluated after the execution of each operation on understanding the experimental phenomenon.

The student should also study the suggested references for further information. The components required for a remote-controlled laboratory, which allow the execution of experiments by students distributed over a wide geographical area, are presented as follows. The essential element is the experiment itself carried out using a functional set of equipment. Measurement and control devices of the sizes to be analyzed are also required. The results obtained as a result of conducting the experiment are analyzed and interpreted using a graphical interface with which auxiliary software programs are accessed. The control and monitoring of measuring devices and equipment is the responsibility of a laboratory server.

The connection between students at a distance and the laboratory server made using the Internet is a dedicated server that can be a complex system of management of learning and learning content (LCMS) that manages both the users and the allocation of time for conducting experiments. This complex component can consist of several servers each performing several tasks/functions: presenting theoretical and practical information about the experiment; user authentication; reserving the execution of experiments. The functionalities can be accessed through a web portal, acting as the first page for the experiments established by an institution or an inter-institutional consortium, offering access to a group of remote experiments. It is necessary to include a server through which the remote student can obtain visual and audio feedback of the state of the experiment. Audio, video and chat communications between users are also required. Client workstations are also needed to ensure remote users connect to the experiment and associated resources. Some remote labs will need to have specific plug-ins or allow the download and installation of client programs to gain access, suitable for the experiment (such as when using platforms that use LabView, MultiSim, etc.).

7 ECEE (Electrical and Computer Engineering Education) Curricula

7.1 Electrical Engineering Education Curriculum

The teaching in undergraduate courses in the STEM (Science, Technology, Engineering, and Mathematics) disciplines has increasingly started adopting the more learner-centered teaching, such as problem based learning.

This shift is fuelled by the need for future engineers to demonstrate the use of higher order thinking, problem solving, and more interpersonal aspects of a career, such as communication, social, and team-work skills (National Academy of Engineers, NAE, 2005). Specifically, the engineering field is seeing shifts in the types of engineers needed to emerge from college who are ready to participate as active and effective members of a global society. The National Academy of Engineers (NAE, 2004) developed a set of attributes future engineers will have to possess to be a competitive force within the field. Hence, it is important for engineering education to re-examine the use of typical lecture-based teaching methodology and consider incorporating learner-centered teaching. One such approach, Problem-Based Learning (PBL) has the potential to help students to cope with the demands of complexities of the field and problems they will face in their future careers.

PBL develops the following skills of students: Teamwork; Project management and leadership; Oral and written communication; Emotional intelligence; Tolerance for uncertainty; Critical thinking and analysis; Application of content knowledge; Research; Decision making; Problem solving across disciplines.

7.2 Computer Engineering Education Curriculum; BTL Course Components and Activities

Instructional model with a BTL approach provides more individualized instruction than traditional face-to-face tuition. It enables learners to accommodate the space/time demands of other interests, as students can carry on other everyday activities without having to adapt to strict space/time constraints. Students can work cooperatively. Cooperative activities help to promote information exchange flows among students, build up cognitive knowledge construction processes, and strengthen motivational and informal affective bonds of mutual support and friendship.

This BTL process as a possible working scenario consists of a 15-week course executed as follows:

The course kicks off with a one-day face-to-face session where the learners have the chance to meet each other and the instructor. The instructor presents the learning objectives, discusses the most significant knowledge and tasks to be learned, and describes computer-mediated interaction (e-mail, chats, and forums).

Every week, there is a 2-h face-to-face session where students ask the instructor questions about the contents they have studied over the last week and discuss problems that they have encountered and possible solutions. The instructor presents the most important contents to be studied over the following week, stressing the concepts that are most important or harder to learn.

One-hour interactions between learners and the instructor are held every week via chat and/or forums to consolidate and acquire knowledge. These sessions are held informally, and their development is not structured. These sessions are especially important for students that were unable to attend the face-to-face session.

There is permanent e-mail support, and queries should be answered within 24 h. Face-to-face support is available to students 6 h a week. Learners can meet the instructor either individually or in groups to clarify contents and receive support on how to solve the good problems.

An online assessment is held every week, where the students have to complete a five-question questionnaire. A final face-to-face assessment is held immediately after the course has finished. Students have to sit a 10-question examination, where they will be expected to complete short exercises on a common problem similar to the ones used in the good problems.

The examination typically lasts 2.5 h. Learner evaluation takes into account the scores achieved in this test, the solution of the weekly questionnaires, the solutions given to the good problems set throughout the course, and the learner's participation in live e-learning sessions.

8 Conclusions

Please Benefits and Challenges of BTL in Engineering Education.

Benefits: LCMS-based BTL has a number of strengths: convenience for learners in having a high degree of control over when and where they engage with course materials and activities; assignments and grades are highly structured, efficient, and have secure management; BTL-based instruction is the learner-centered on critical thinking that can be generated in properly structured LCMS discussion boards. *Challenges:* innovative online instructors have to develop many creative ways of using LCMS discussion boards to cultivate interaction and sense of community. Faculty Professors and Students need to learn new pedagogies to adopting BTL.

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Optimization of Curricula of Engineering and Pedagogical Specialties Based on the Construction of a Model for Structuring Interdisciplinary Relations

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Abstract. The paper discusses various methods for the Educational Data Mining (EDM), including curricula, based on interdisciplinary teaching. Their advantages and disadvantages are being discussed. The problem of interdisciplinary teaching in engineering and pedagogical education has its own specifics, which is due to the fact that, in essence, this education is complex interdisciplinary, and the training of future teachers of vocational institutions has been implemented at the border of pedagogical and engineering sciences. The authors propose a method for optimizing the curricula of engineering and pedagogical specialties based on the algorithm of phased construction model for structuring interdisciplinary relations. This method is based on the graph theory. The result of the method has been presented as a graph of interdisciplinary relations in tier-parallel form. The construction of the graph and solving the problem of interdisciplinary integration has been implemented using software developed by the authors, the description of which is given in the paper. The paper also discusses the results of optimization.

Keywords: Vocational education · Vocational institution teacher · Integrative education · Curriculum · Interdisciplinary relation · Competencies · Matrix of interactions · Graph

1 Problem Statement

A characteristic tendency for pedagogical education of the 21st century is the transition from subject to integrative learning, which allows, under the conditions of a competency-based approach, to resolve the contradictions existing between the disparate assimilation of knowledge and the need for its synthesis. However, to resolve these contradictions is possible only if the interdisciplinary relations are optimized.

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Such optimization should ensure the logical interconnection of the subjects of the natural science and natural humanitarian cycles and their connection with the professional training of future specialists. The solution to this problem is especially relevant for the training of future teachers of vocational institutions, since the problems that they have to solve in the process of professional pedagogical activity arise at the border of pedagogical and other sciences [1].

One of the main factors affecting the quality of training of future teachers is the quality of the educational process organization, which, inter alia, depends on the logical sequence of the educational material presentation. Today, every teacher in preparing the academic course focuses on the syllabus and the work program of the subject matter. This raises the question: to what extent are these documents logically consistent and correct, as well as provide interdisciplinary relation? Indeed, when preparing the training course, a number of problems arise: what key concepts should be included in the presentation with a limited amount of hours for a subject matter; what should be the structure of the educational material so that the logical integrity of the material is not violated (that is, there should be no logical "failures", duplication of material, running ahead, unrelated parts of the training material, etc.); how to ensure the continuity of educational material and the like.

2 Analysis of Recent Research and Publications

The problem of determining the optimal structure of educational material has acquired particular relevance in the 70s of the last century with regard to the beginning of the introduction of teaching aids into the educational process. In pedagogy, two main methods of formal structuring of educational material are known: the matrix method and the graph method [2–4], based on constructing the matrix of concept interactions and the concept graph, respectively. The matrix method consists in the fact that a teacher or a group of teachers conducts a heuristic analysis of the matrix of interactions between the subject concepts for its correctness and optimality in accordance with some requirements. The graph method involves formalized work with a graph of concepts based on a specific mathematical apparatus.

Automation of this process is included in one of the modern scientific fields - Educational Data Mining (EDM), which implies the development of methods for studying data arising in an educational context [5]. So, the authors of [6], on the basis of a previously developed software tool, construct a logically consistent sequence of educational material presentation of a certain subject matter. For this purpose, many concepts of the subject are formed, a matrix of their interactions is built, and a ready-made software product that determines the order of presentation of topics is used.

In [7], an extensive study on the automation of various aspects of the educational process has been provided. Three optimization problems related to content modeling: concept graph learning, coherence evaluation, and modular curriculum planning have been described. The mechanism for establishing the interdependence between key concepts of content and subject matters is of interest from the perspective of this study. The authors of [8] analyze the model of "statistical relational learning" by analyzing the weighted and undirected graph, which is based on a Markov-chain model of a random walk through the database. The papers [9, 10] describe the results of the interdisciplinary research based on the EDM. In this context, issues of forecasting student grades, automation of the process of building subject matters, etc. have been highlighted.

The paper [11] proposes the optimization effectiveness model of the curriculum system based on multidimensional satisfaction fusion. At the same time, each participant in the educational process assesses his/her satisfaction with the result of studying a certain topic and, depending on these assessments, the trainees are offered to master the following topic, which may have undergone operational adjustments, that is, the process of constructing the curriculum is interactive, according to the available results, and an optimal model of further education is being built. The authors of [12] have presented a method for the automation of curriculum development, which is based on the graph theory. Using this method, the curriculum structure is improved by the criterion of the general significance of the content modules of academic subjects. Through the use of ASP.NET and Microsoft SQL Server technologies, a software tool that implements an image of a structurally-logical learning scheme, divided into layers, has been designed. The result of the method is a list of subjects with semesters in which it is recommended to study these subjects. However, the disadvantage of this method is the subjectivity of expert assessments, which forms the input modules of academic subjects and estimates their significance coefficient.

In [13], optimization of the curriculum with the value chain theory, according to the results of external and internal resources factors, has been proposed. In [14], an optimization of the curriculum based on a knowledge network, which is understood as a network structure formed by many knowledge chains, has been proposed and each intersection can be understood as a node in the knowledge network. However, the authors of the works do not present effective optimization mechanisms expressed in rigorous algorithms and real software products.

An analysis of the research results presented allows us to highlight the main stages in building a logical chain of subjects for the training of future specialists based on the use of the interdisciplinary approach. These are the following stages: determination of key units of information and subjects in which they are stated; establishing their relationship in the form of a matrix and a graph; optimization of such a graph in order to obtain a logically coherent chain of academic subjects for the training curriculum formation; development of a curriculum based on the information received, in accordance with established requirements (the number of full-time and total hours of classes in each semester; the number of midterm controls for each semester; periods and duration of semesters, etc.). To date, a unified approach that would ensure the implementation of all the above steps does not exist.

The purpose of this study is to develop on the basis of the interdisciplinary approach such a procedure for compiling a logically consistent chain of academic subjects for the training of teachers of vocational institutions, which would cover all of the above stages.

3 Statement of Basic Material and the Substantiation of the Obtained Results

Training in the system of higher engineering and pedagogical education is based on standards developed on the competency-based approach. Each competency contains a list of relevant knowledge and skills, the formation of which occurs in the process of studying certain educational subjects [1], that is, the formation of specific competency occurs through the integration of knowledge and skills in various academic subjects, which indicates the possibility of applying an interdisciplinary approach to the formation of educational content.

Designing the educational process on standards causes certain difficulties, since they do not contain a ready-made list of subject matters distributed by type of training. Therefore, the task of teachers is to formulate a list of these subjects, design their content and to combine it organically on the basis of interdisciplinarity in the formation of certain general and professional competencies. After determining the list of such subjects, the time for studying them and designing their content (that is, working curricula), we can develop a curriculum for training future teachers of vocational institutions. For this, first of all, it is necessary to analyze the competencies that a specific specialist should possess, knowledge and skills that contribute to their formation. It is knowledge and skills that allow us to highlight the concept and actions that future teachers should know and be able to perform. The concept and actions, in turn, allow them to be attributed to a specific academic subject. Thus, each subject can be represented as a set of its basic, key concepts. After defining many concepts, it is necessary to determine their dependence on each other. Moreover, for each concept, it is necessary to indicate a subset of the concepts depending on it. The combination of many concepts obtained as a result of the analysis of all the competencies of the standard allows us to get an overall picture of the relationship between the key units of training of future teachers. After identifying many concepts to build their optimal sequence, in which there are no repetitions and running ahead in the training material presentation, it is necessary to implement the following algorithm based on the graph theory:

1. To build a diagram of the relationship of concepts (graph $G = \{V, \Gamma\}$). Here $V = \{v_i\}, I = 1, N$ is the set of the integral units of knowledge (concepts), and Γ is the set of directed arcs $U = \{u_{kl}\}$ that connect the pairs of the graph nodes. The arcs $u_{kl} \in U$ correspond to the flow of information transfer from one integral unit of knowledge to another (interactions between them).
2. To construct a square matrix of interactions $M = \|m_{ij}\|$ using graph G. The dimension of the matrix is equal to the number N of selected concepts (the cardinality of the set V). Fill the cells of the matrix as follows: if the element v_1 is connected with the element v_2 ($v_1 \to v_2$), then at the intersection of the 1st row and the 2nd column, we put one ($m_{12} = 1$), otherwise—zero ($m_{12} = 0$). Diagonals of the matrix always have zeros ($m_{kk} = 0, 1 \leq k \leq N$), because an element cannot be connected to itself.

3. To summarize each row and each column of the matrix separately. These sums in the column and in the row show the number of outgoing and incoming links for each graph node (that is, the number of incident arcs for each node) and form vectors whose dimension is equal to the number of rows and the number of columns of the matrix of interactions. We denote them as follows: W_a is a row vector, W_b is a column vector.
4. To analyze the graph (matrix of interactions) in order to identify contours and "autonomous" nodes in it.
5. To decompose W_a vector into layers. Each of the layers forms a vector. Let us denote these vectors by $V(z)$, where z is the layer number ($z \geq 0$). The dimension of these vectors (the number of elements of each layer) is determined in the process of W_a vector decomposition into layers. We denote the elements of vectors by $v_i(z)$, where $i \geq 1$.
6. To construct graph G1 in tier-parallel form using the resulting partition. Graph G1 is an optimized curriculum model. Transition of the graph into a tiered-parallel form leads to the fact that the graph is represented as tiers of mutually unrelated concepts. The most important and essential for further research is the first tier, which determines the number of logically completed topics and the initial concepts of each of the topics. The final determination of the quantity and content of topics occurs during the analysis of the graph in tier-parallel form.
7. To analyze graph G1 and to develop recommendations on the sequence of the educational material presentation. An analysis of the optimized curriculum model consists in constructing the sets $C_{vj} \subset V$ for some v_j from V. The set C_{vj} consists of elements v_k from V $(k \leq N)$ that should be learned before studying the concept of v_j, i.e. before starting v_j, it is necessary to state all the elements of the set C_{vj}.

The analysis of the graph in a tiered-parallel form allows us to generally consider all the tiers of the graph and to determine the logical chain of presentation of the concepts inherent in the competencies of the standard to students. As a result of the analysis, the structural-semantic model of educational material (G_1) is divided into a number of subgraphs in a tiered-parallel form, each of which is a structural model of a single subject. Thus, a clear structure and a sequence of the educational material presentation in the subject matters will be obtained. Next, we develop a curriculum in accordance with the established requirements, as described in the paper [15].

Thus, the task of optimizing the curriculum for engineering and pedagogical specialties, which consists in building the optimal sequence of the educational material presentation, where: a) each concept belonging to the layer k is not stated earlier than any related concept belonging to the layer $k - 1$; b) each concept occurs only once, will be solved. We will consider the technology for designing the educational process described above using the example of training engineers and educators (future teachers of vocational institutions) in the "Vocational Education (Power engineering)" educational program. A future specialist in this specialty should have formed general and professional competencies. Since professional competencies are of more interest to our research, we will choose one professional competence from the entire list, on the example of which we will demonstrate the technology for designing the educational process described above. The professional competence - the ability to carry out maintenance and operation of equipment for thermal automation and measurement equipment based on knowledge of the structure and principles of operation of measuring and automation tools - was selected as such.

The next step involves the analysis of knowledge and skills that contribute to the formation of appropriate competence. These knowledge and skills made it possible to identify 30 concepts and actions that a future specialist should know and be able to perform. In particular, he/she should know the arrangement and the principle of operation of measuring and automation means, the main and auxiliary equipment of the power unit, the thermal circuit of the power unit, the operating parameters of the main and auxiliary equipment of the power unit, and the like. Also, the future teacher of vocational institutions on the "Vocational Education (Power engineering)" educational program should be able to carry out an external examination of measuring instruments and automation, to disassemble (to fold) measuring instruments and automation, to replace faulty elements, to check and to regulate their work, to control the functioning of measuring instruments and automation in operating mode, etc.

The listed components of the competency under consideration relate to certain academic subjects, namely: "Electrical Methods and Means of Measurement", "Installation, Operation, and Diagnostics of Electrical Equipment", and "Industrial Training". In the next step, we establish the relationship between the selected elements and build a matrix of the concept interactions. Further work on the study of the logic of the material presentation for the professional competence formation, namely, constructing a graph of concepts, converting the graph into a tiered-parallel form, analyzing the matrix of interactions, has been automated and carried out using the software developed by the authors. The program implements well-known algorithms for working with graphs (identifying "contours", "autonomous" nodes, translating a graph in a tiered-parallel form) and analyzing the graph in a tiered-parallel form. The program has been developed using the Visual Basic for Application design environment for MS Excel. Using the developed program, a concept graph has been constructed in a tiered-parallel form (Fig. 1).

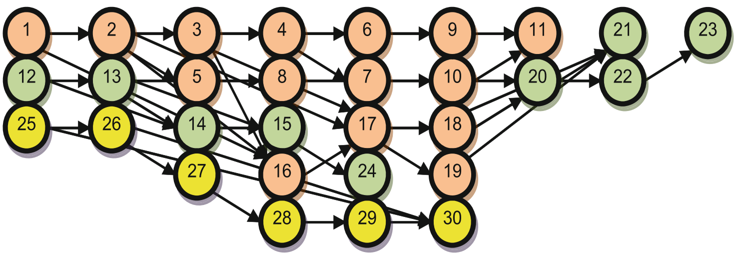

Fig. 1. Graph of concepts in a tier-parallel form

Based on this graph, we can formulate a logical sequence for the educational material presentation in the subjects of the curriculum for the professional competency formation of future teachers of vocational institutions under the "Vocational Education

(Power engineering)" educational program. In the first place in the curriculum should be the subject "Electrical Methods and Means of Measurement". In this subject matter, the following concepts are consistently stated: 1. Means of measurement and automation; 2. The construction of measuring and automation; 3. The principle of operation of measuring and automation; 4. Control panels; 6. Panels; 9. The location of the panels; 7. Location of control panels; 10. Flow diagrams; 11. Location of equipment for measuring and automation equipment; 16. Technical description of measuring and automation equipment; 17. Instruction manual for measuring and automation equipment; 18. Structural schemes of protections; 19. Structural signaling schemes 5. Remote controls; 8. Location of remotes.

The "Installation, Operation, and Diagnostics of Electrical Equipment" subject should be in second place in the curriculum. In this subject, the following concepts are consistently stated: 12. The thermal flow diagram of the power unit; 13. The main equipment of the power unit; 14. The auxiliary equipment of the power unit; 15. The parameters of the main and auxiliary equipment; 24. To navigate in the range of available measuring instruments and automation; 20. Block diagrams; 21. The response algorithm of technological protections; 22. Megger up to 500 V; 23. Rules for using a megger up to 500 V. The last subject in the unit of competency formation is "Industrial Training". In this subject, the order of the concept presentation is as follows: 25. To perform an external inspection of measuring and automation equipment; 26. To disassemble (to fold) the means of measuring equipment and automation; 27. To replace faulty elements, to check and to regulate their work; 28. To check the functioning of measuring instruments and automation in the operating mode; 29. To regulate kinematics, balancing; 30. To prepare thermal automation and measurement tools for verification and calibration. As can be seen from Fig. 1, the first tier of the graph includes 3 concepts (1, 12, and 25), which corresponds to the belonging of the analyzed concepts to 3 different subjects. The initial concepts of disciplines should be concepts 1 (Means of measurement…), 12 (The thermal flow diagram of the power unit) and 25 (To perform an external inspection…). The transition to the study of the next subject is carried out after mastering all the concepts of the previous subject.

Thus, the optimal sequence of the formation of one of the professional competencies has been obtained. Similarly, an analysis of all the competencies indicated in the educational program (which is developed on the basis of the standard), as well as the knowledge and skills that ensure their formation has been made. This allows us to determine the complete list of concepts and actions necessary for the assimilation and implementation of the future teacher and to define the logical chain of interrelated academic subjects that should make up the curriculum on their basis.

4 Conclusions

A method for optimizing the curriculum of engineering and pedagogical specialties based on the algorithm for the phased construction of a model for structuring interdisciplinary relations has been developed and implemented at the Ukrainian Engineering Pedagogics Academy. The method has been implemented with the author's software tool that represents the connection of concepts in a tiered-parallel form, and the sequence of presentation - in the form of a chain of concepts related to certain subjects. The program is written in VBA and is available for use. The construction of a logically consistent chain for presentation of interrelated concepts contributes to the development of the correct curriculum for the training of future teachers of vocational institutions based on an interdisciplinary approach.

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Mastering the Electronic Educational Environment of a University by Educators with a Different Overall Digital Competency Index

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Abstract. The article describes the approach to the digital competency. Today the generalized knowledge of the humankind has been digitized and materialized in the technical environment. It can be easily accessed anytime and from anywhere and has become practically indestructible as it has been repeatedly duplicated. In the 21st century, we are dealing with a different subject of education, a network persona who has an extended range and faster pace of interaction. As a result, each individual can now exercise a greater degree of influence on the environment, whereas self-organizing capabilities of groups are growing. The question is, are the educators ready for this challenge? They handle these challenges differently and experience various kinds of problems and difficulties. The survey was conducted. The respondents were teachers of humanities in technical university. The digital competency index for each respondent was calculated, and then the mean value of digital competency among teachers of humanities in a technical university was found. It was revealed that the respondents manifested the highest competence in the field of content, and were least competent in communication, which shows how important it is to develop communication in the digital educational environment. The data obtained were also processed using mathematical statistics by applying Fisher angular transformation. A program for psychological and educational support for the educators in the process of mastering Learning Management System Moodle was developed.

Keywords: Digital competency index · Learning management system · Online personality

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1 Context

Electronic educational environment is presently under fast implementation into the professional education worldwide. As organizers of the learning process, university professors have to master new skills in order to navigate the new environment and solve unprecedented academic and professional tasks [1].

Universal informatization and changes in personal qualities give rise to new competencies related to mastery of the ICT and communication in the digital environment.

In 2017, the Northwestern Regional Center of Online Education Competence was created under the auspices of Peter the Great St. Petersburg Polytechnic University. The University is investing its efforts in developing the electronic information and education environment.

Two of the most important educational elements of the electronic information and education environment at Peter the Great St. Petersburg State Polytechnic University are massive open online courses published on the Open Education National Platform and Coursera international training platform and learning management system (LMS) Moodle.

According to its definition, a learning management system is a software application that enables management of training courses in the process of online education [2]. The definition includes the word “manage”. This means that, apart from uploading prepared content to the system, we can also manage accessibility of materials to each individual user at a certain point in time. The learning management system also helps easily change course settings, classify, add or delete materials and assignments in two clicks, change the educational trajectory for the entire group or individual students, and track the digital footprint of each student. All these functions and how fast this can be done in the LMS define the possibilities for customized training process for each learner.

However, according to the surveys, educational platforms and Massive Open Online Courses (MOOCs), as well as online education in general, albeit extremely accessible and easy to use for consumers, are not universal in their application. Tens of thousands of learners start these programs, but 90% of students drop the course before they receive their certificate. Experts say that a large number of dropouts in these courses has to do with a lack of motivation and depends on the initial goal of starting MOOC [3]. Unconditionally, it is important to focus on creating massive open online courses at open educational platforms. However, due to the aforementioned reasons, it is equally important to organize psychological and pedagogical support so that educators improve their mastery in learning management systems and acquire new digital competencies in order to “be in the trend” and fit in with the modern paradigm of educational development to teach in-demand specialists on the labor market [4].

2 Purpose

Today the generalized knowledge of the humankind has been digitized and materialized in the technical environment. It can be easily accessed anytime and from anywhere and has become practically indestructible as it has been repeatedly duplicated. In the

21st century, we are dealing with a different subject of education, a network persona who has an extended range and faster pace of interaction. As a result, each individual can now exercise a greater degree of influence on the environment, whereas self-organizing capabilities of groups are growing. The question is, are the educators ready for this challenge? They handle these challenges differently and experience various kinds of problems and difficulties. We believe that their ability to deal with the situation depends on overall development level of their digital competencies.

The purpose of the study is to explore the relationship between the digital competency index and LMS Moodle operating skills, and to find out if educators are interested in participating in the program of psychological and educational support of pedagogical activities.

3 Approach

3.1 Digital Competency

The research draws on the following approaches to the problem: the history sphere approach (Sazonova-Akhayan) [5], the subject designer approach, the universal designer approach (Patarakin) [6], and the mobile revolution approach (Polivanova-Koroleva) [7].

In the information society, the concept of "literacy", which has always been associated with education and implied, primarily, a combination of the three most important competencies – reading, writing and counting – has significantly expanded its limits. The emerging and intensely developing concepts in the current educational system are "computer literacy", "information literacy", "media literacy", "ICT literacy", and "digital literacy" (Gilster) [8].

Since recently, the concept of "digital literacy" is becoming increasingly popular. In this concept, the researchers are trying, on the one hand, to bring together various types of ICT-related literacy and, on the other hand, to define the competencies needed in today's world due to wide spread of Internet across the globe. Research has shown that emergence of this concept is related to the fifth literacy revolution, the invention of the Internet. Thus, the beginning of the new millennium gave rise to the "new literacy" concept which now combines academic and digital literacy.

The concept of digital literacy is closely interrelated with the concept of digital competency.

The concept of digital competency has been actively developing and changing as modern information and communication technologies develop. According to most authors, the concept of digital competency includes the skills required to effectively use digital technologies in everyday life, abilities and skills for critical assessment of technologies, motivation to participate in the digital culture, and technical skills mostly related to computer literacy.

The concept of digital competency is further developed through the notions of digital culture and digital citizenship.

Today digital culture is part of everyday culture of any member of the information society, and is equally subject to regulation through laws, ethical rules of conduct and safety rules jointly established by members of this society. Digital competency also acquires a social aspect.

The approach offered by G.U. Soldatova [9] defines digital competency as the ability of an individual to confidently, efficiently, critically and safely select and apply information and communication technologies in different areas of life (working with content, communications, consumption, technosphere) based on continuous mastering of competencies (a system of relevant knowledge, skills, motivation and responsibility).

3.2 Digital Competency Index

The approach offered by G.U. Soldatova defines digital competency as the ability of an individual to confidently, efficiently, critically and safely select and apply information and communication technologies in different areas of life (working with content, communications, consumption, technosphere) based on continuous mastering of competencies (a system of relevant knowledge, skills, motivation and responsibility).

Soldatova includes both motivational and value-oriented spheres of a personality [9]. The concept's structure includes needs and desires of a person, the extent of readiness to develop (motivational sphere) and attitude to internet, degree of understanding and acceptance of norms, rules and values of the digital world and readiness to follow them (value-oriented sphere). For our diagnostics, we use the Digital Competency Index (designed by G.U. Soldatova, T.A. Nestik, E.I. Rasskazova, E.Y. Zotova) as well as the authors' questionnaire for determining Moodle LMS user competency skills (designed by K.P. Zakharov, O.O. Kunina). According to Soldatova, digital competency index consists of four categories Knowledge, Motivation, Responsibility, Skills, and four areas Content, Technosphere, Communication, Consumption.

The purpose of the specially designed questionnaire "Moodle learning management system skills" (K.P. Zakharov, O.O. Kunina) was to determine the teachers' experience with Moodle, as well as to define which elements the teachers were familiar with and which elements they would like to study.

3.3 Educators' Role Positions in LMS Moodle

SPbPU makes use of the Moodle LMS for its educational needs.

Moodle learning management system became popular and widespread because of its technical parameters and multiple built-in tools. All tools can be subdivided into four groups. The first group includes tools that enable presentation of theoretical materials for learners to study. The second group includes tools for formative and final assessment. LMS Moodle also includes tools for peer assessment, which gives students an opportunity to rise to the highest level of cognition in Bloom-Anderson's taxonomy [10]. The third group of tools in Moodle enables communication in scope of a course or during a particular lesson. Finally, the fourth group, reporting, helps to track the students' progress, to monitor their attendance of classes and track statistics on passing tests and completing assignments.

Using the entire range of Moodle LMS tools, an educator can act in different roles in relation to the students. The first position is moderator-coordinator. He establishes contacts with students, introducing them to the educational environment and demonstrating its capabilities. The trainer can become a mentor and show on his or her own example what must be done and how (hard-skills). The trainer can also be a facilitator who, apart from being a role model of the desired result, provides feedback to students, determines their level of current development and sets new, previously unknown tasks that students will try to solve on their own, using their new knowledge (development of soft-skills). Additionally, the facilitator shapes the academic community. The trainer can also act as a tutor. The tutor has all the qualities of a facilitator, but in this role he or she also helps students not only to advance within the discipline under study, but also to reflect on their progress in the interdisciplinary context (self-skills). Moodle learning management system offers enough tools for the educator to assume various roles in the educational process.

3.4 Sample Description

The research included 45 respondents who were teachers of humanities in a technical university. 39 of them were women and 6 – men.

Among the respondents, 23 individuals had an advanced degree, 20 had university degrees with no advanced degrees, and 1 person had complementary professional postgraduate education.

The respondents were grouped in accordance with the adapted Howe-Strauss theory of generations. The participants belonged to the following generations:

- Baby boomers – 6;
- Generation X – 15;
- Generation Y – 24.

Due to the small number of the Baby Boomers group, we consolidated Millennials and Baby Boomers into one group for further processing the data using mathematical statistics methods. Consequently, we continued with comparing two groups: the younger and the older generations.

3.5 Survey Results

The digital competency index for each respondent was calculated, and then the mean value of digital competency among teachers of humanities in a technical university was found.

The mean digital competency basic index amounted to 54.9%. The values were almost equally divided among the spheres:

- Content – 58%
- Technosphere – 54.6%
- Communication – 51.4%
- Consumption – 55.8%

This data shows that the respondents manifested the highest competence in the field of content, and were least competent in communication, which shows how important it is to develop communication in the digital educational environment.

The respondents filled out a specially designed tool entitled “Moodle LMS Skills” (K.P. Zakharov, O.O. Kunina). It was discovered that 34 of them completed a training course in Moodle operation, while 6 respondents didn’t but would like to (75.6% and 13.3%, respectively). Most respondents were generally satisfied with the course (55.6%), however, some respondents (30.6%) said they could not transfer their theoretical knowledge into practice.

A total of 37 out of 45 respondents (82.2%) said they would want to learn more about the Moodle LMS. A total of 86.7% of respondents reacted positively to the proposal of providing remote support to educators in the process of their adaptation to the university’s digital learning environment.

The survey showed that the most popular tools among the educators were Questionnaire, Glossary, Lecture, Feedback, Survey, Attendance, Seminar, Test, Chat, Hyperlink, Book, Folder, Explanation, Test.

This shows that generally the educators can operate the basic instruments of the Moodle Learning Management System to organize the educational process using this tool.

The tools that educators are interested in and would like to study are Videoconferencing, Interactive content, Oral response module. This testifies to the fact that there is a lack of personal interaction in the digital environment, and this is what teachers aspire to learn.

The data obtained were also processed using mathematical statistics by applying Fisher angular transformation. We were looking for significant differences between two cohorts – the group of respondents under 37 and the group of respondents after 37. The statistical analysis revealed differences in three categories: the primary index of digital acumen (at the significance level $p < 0.01$), skills (at the significance level $p < 0.01$) and communication (at the significance level $p < 0.05$).

The younger group representatives show higher digital acumen Index, which becomes manifest mainly in the Skills category. No significant differences were revealed in the categories of Knowledge, Incentive and Responsibility.

As for the areas of digital acumen, there were significant differences discovered in Communication: the younger generation demonstrates a higher level of digital acumen in this area. No significant differences were revealed in the areas of Content, Consumption and Technosphere. There were no significant differences revealed in the level of Moodle Learning Management System proficiency either.

4 Conclusions

Since the communication sphere scored lowest in the survey, it is important to implement network interaction forms in the digital educational environment.

We have developed a program for psychological and educational support for the university teachers in the process of mastering Moodle learning management system. The program uses network-based education forms. Structural elements of the system are as follows: participants of the learning process; informational educational resources that are already available or created by the participants in the process of education, interaction between the participants through the network service.

The program is based on the concept of academic content mastering levels by V. P. Bespalko and the Disciplinary Matrix by T. Kuhn as applied to education. Training can be provided at three levels:

1) practical skills (primary training) – concrete actions;
2) meta-subject skills (secondary training), such as 4K;
3) methodological reflection (tertiary training) – what stands in the way of my professional development.

In the process of implementing the program, teachers will gradually learn how to arrange the educational process with the help of Moodle learning management system. The program covers all elements of Moodle LMS which the users can encounter while organizing the educational process.

Moodle LMS and all its capabilities are just a tool in the educator's hands. He or she uses it to embody his or her own vision and deliverables of the course. As any tool, it can be used at different levels – reproductive and productive levels of human activities.

Fluency in the new modern tools will allow teachers to avoid difficulties in implementing it in the educational process, will allow them to organize new forms of dialogue with students, will help them in building an effective individual educational route. However, we emphasize that online and offline learning is not seen as a substitute for each other, but only as mutually complementary forms.

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Case Study on the Engineering Academic Staff Needs and Competencies in the Context of Sustainable Development

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Abstract. Education for Sustainable Development (ESD) **is** education that encourages changes in knowledge, skills, values and attitudes to enable a more sustainable and just society for all. However, competence of educators is a major challenge in achieving ESD. **The purposes of this study are** to determine the awareness of the engineering academic staff on the goals of sustainable development (SDGs), evaluate their **current competence, as well as** to identify engineering academic staff educational needs in connection with the integration of sustainable development (SD) issues in the study courses led by them. The study includes components that characterize engineering academic staff educational needs: knowledge, skills, professional competence, motivation to work with SD issues, etc. The results of the survey show that a relatively small proportion of respondents are very familiar with the SDGs. Only in some cases, SDGs and environmental issues were integrated into all professional subjects and courses. Professional competence is mentioned as one of the most important competencies that should be developed by the academic staff. The engineering academic staff also needs to improve the didactic materials. At the same time engineering academic staff in Latvia have a deep understanding of the dimensions of sustainable development and its significance in engineering education.

Keywords: Engineering education · Sustainable development goals

1 Context

Increasing concerns about the human impact on the natural environment, in 1987, the World Commission on Environment and Development defined the concept of **sustainable development** as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [1]. Of course, meeting human needs and improving the quality of life requires development, but it must take place without exhausting the capacity of the natural environment. Initially, sustainable development policy emphasized the environment, but since 2002, it has also included social justice and the fight against poverty.

To address urgent global challenges over the next 15 years, on 1 January 2016, the world officially launched the transformative plan of action "The 2030 Sustainable Development Agenda" announcing 17 Sustainable Development **Goals** (SDGs) with 169 related targets [2]. Sustainable Development Goals are: 1) No poverty; 2) Zero

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hunger; 3) Good health and well-being; 4) Quality education; 5) Gender equality; 6) Clean water and sanitation; 7) Affordable and clean energy; 8) Decent work and economic growth; 9) Industry, innovation and infrastructure; 10) Reduced inequalities; 11) Sustainable cities and communities; 12) Responsible consumption and production; 13) Climate action; 14. Life bellow water; 15) Life and land; 16) Peace, justice and strong institutions; 17) Partnerships for the goals.

Education can make a major contribution to achieving these goals, which should contribute to a new vision of sustainable global development [3]. According to UNESCO (2015), the challenge for educational institutions today is the integration of SDGs into the educational process. This is indicated by target 4.7, which specifies the role of education in development and expects that by 2030 all learners will acquire the knowledge and skills needed to promote sustainable development.

The role of education is also emphasized in SDGs target 13.3. "Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning" [5]. Education, awareness-raising and public awareness play a key role in increasing the capacity of communities to combat and adapt to climate change [6]. The document also states that climate change must be integrated into school curricula at all levels and in different disciplines.

Education for Sustainable Development (ESD) was a United Nations program that defined as education that encourages changes in knowledge, skills, values and attitudes to enable a more sustainable and just society for all [7]. Agenda 21 was the first international document that identified education as an essential tool for achieving sustainable development and highlighted areas of action for education [8].

Particular attention should be paid to the engineering programs, as engineers contributes to a sustainable society in the present and the future, effective and efficient use of resources, looking for different opinions. Undoubtedly, it is educators, their competence, motivation and working conditions that are currently the most important factors in promoting the goals of sustainable development. The educator can provide learners with tools and resources to explore engage and understand the importance of sustainability. When learners are empowered with knowledge, critical reflection tools, and media literacy, they are better prepared to act and make changes for themselves and others around the world [9].

2 Purpose or Goals

Despite the above, educators identify lack of systemic approach for SDGs implementation working in higher engineering education. There are policy mechanisms and different declarative documents but systemic implementation guidance and daily working manuals to reach local, national, European and worldwide context for engineering academic staff are missing.

In view of the above considerations, the purposes of this study are:

- to determine the awareness of the engineering academic staff on the goals of sustainable development, evaluate their current competence, as well as

– to identify engineering academic staff educational needs in connection with the integration of sustainable development issues in the study courses led by them.

The study includes several components that characterize engineering academic staff educational needs: knowledge, skills, professional competence, motivation to work with sustainable development issues, etc.

3 Approach

To achieve sustainable development, society needs intelligent members of society. H. Gardner in his book from 1983 "Frames of Mind" gave seven separate forms of human intelligence: linguistic, logical-mathematical, spatial, musical, body-kinaesthetic, interpersonal and intrapersonal [10]. Daniel Goleman in 2009 put forward a new concept - **ecological intelligence**, which focuses on the ability to understand the impact of our actions on the environment or, in Goleman's words, "the ability to adapt to our ecological niche" [11]. This means understanding the relationship between organisms and their ecosystems, as well as the ability to obtain cultural information, learn from experience and adapt to the environment without harming it. Ecological intelligence also means "ecological literacy", which is defined as the ability to "read" and interpret current environmental problems and the relationship between humans and nature [12]. The question is how can we **develop** our **ecological intelligence**? The solution could be to increase our awareness [13]:

1. The first step in developing our intellect is to become more aware of what we are doing. It is important to know how our daily decisions can affect our world and society (what food do you buy, how often do you drive, how much energy do you use, etc.).
2. The second step is to make our habits more sustainable so that we can completely transform our lifestyles to create a better world for future generations to enjoy. Unfortunately, this could take years.

Education for Sustainable Development (ESD) is defined as education that encourages change in knowledge, skills, values and attitudes to ensure a more sustainable and just society for all [14]. It gives people the opportunity to change their way of thinking and working towards a sustainable future. The ESD aims to enable current and future generations to meet their needs through a balanced and integrated approach to the economic, social and environmental dimensions of sustainable development. Wals A.E. has defined four competence-based **dimensions** of sustainability: [15]:

– the dynamics and content dimension of sustainability,
– the critical dimension of sustainability,
– the change and innovation dimension of sustainability,
– the existential and normative dimension of sustainability.

Wiek A. et al. developing the basic principles of academic program development, identified five **key competencies in sustainability** [16]:

- systems thinking competence,
- anticipatory competence,
- normative competence,
- strategic competence,
- interpersonal competence.

In 2016, they added the sixth competency:

- integrated problem-solving competence

In 2016 Glasser H. and Hirsh J. identified **five additional key competencies** [17]:

- affinity for life,
- knowledge about the state of the planet,
- wise decision- making,
- modelling sustainable behaviour and
- transformative social change.

Based on the above, sustainability indicators depend on the interaction of knowledge and skills, value and motivation drivers, and opportunities. The interrelationship of these dimensions influences personal behavior (see Fig. 1).

Fig. 1. Key competencies and performance of sustainability citizens (source Rieckmann M. [18]).

The Joint Ministerial Session on ESD [19] recognized that the big problem in achieving ESD is the **competence of educators** and agreed that competence development in the EDD should be one of the priorities for further implementation of the UNECE strategy. Expert group set up by the UNECE Steering Committee on ESD, developed general recommendations policymakers for the development of competences across all sectors of education, with particular emphasis on formal education and a range of core competences in ESD for educators, to serve as a tool to facilitate the integration of ESD into all educational programmes at all levels [20].

The competences for educators in education for sustainable development contain a set of categories that reflect a wide range of learning experiences (see Fig. 2):

– *Learning to know* means an understanding of the challenges facing society learners (*The educator understands….);*
– *Learning to do* refers to developing practical skills and action competence in relation to ESD (*The educator is able to*….);
– *Learning to do* refers to developing practical skills and action competence in relation to ESD (*The educator is able to*….);
– *Learning to be* addresses the development of one's personal attributes and ability to act with greater autonomy, judgement and personal responsibility in relation to SD (*The educator is someone who*….).

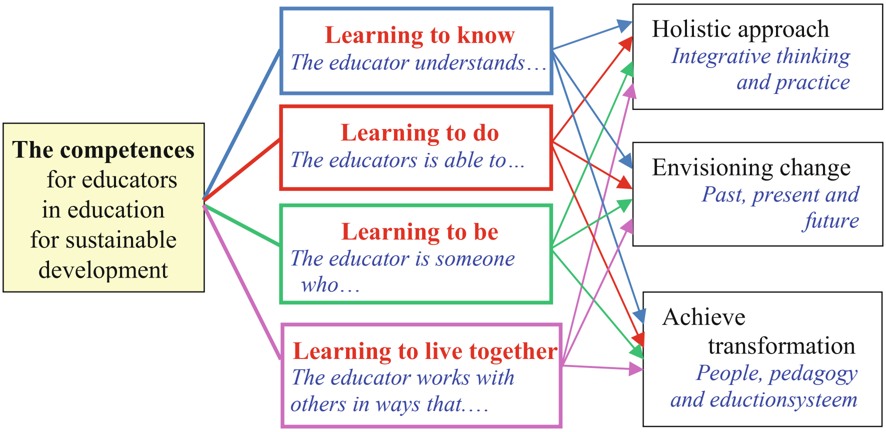

Fig. 2. The competences for educators in education for sustainable development.

These categories should be applied and provided for:

– A *holistic approach*, which seeks integrative thinking and practice. The holistic approach includes three interrelated components: integrative thinking, inclusivity and dealing with complexities.
– *Envisioning change*,(past, present and future) which learns from the past, engages in the present and explores alternative future possibilities.
– *Achieving transformation*, which serves to change in the way people learn and in the systems that support learning.

Awareness of learning objectives for teachers is essential for the successful promotion of EDS. Learning objectives for teachers to promote ESD are listed in a UNESCO 2020 [21]:

– Know about sustainable development and the related topics and challenges;
– Understand the discourse on, and the practice of ESD in the local, national and global context;

- Develop an integrative view of the key issues and challenges taking into account social, ecological, economic and cultural dimensions from the perspective of the principles and values of sustainable development;
- Develop disciplinary, interdisciplinary and transdisciplinary perspectives on issues of global change and their local manifestations;
- Reflect on the challenges facing promotion of the concept of sustainable development and the importance of their field of expertise for facilitating sustainable development and their own role in this process;
- Reflect on the dynamics of formal, non-formal and informal learning for sustainable development, and apply this knowledge in their own professional work;
- Understand the ways in which cultural diversity, gender equality, social justice, environmental protection and personal development are integral elements of ESD and how they can be made a part of educational processes;
- Practise an action-oriented transformative pedagogy that engages learners in participative, systemic, creative and innovative thinking and acting processes in the context of local communities and learners' daily lives;
- Act as a change agent within a process of organizational learning to advance the school towards sustainable development;
- Identify local learning opportunities related to sustainable development and build cooperative relationships;
- Evaluate and assess learners' development of cross-cutting sustainability competencies and specific sustainability-related learning outcomes.

The empirical part of the research is based on the survey of engineering academic staff carried out at different engineering universities in Latvia. The questionnaire included three types of questions: (1) respondents were given several statements and asked to mark the correct option; (2) most of the answers to the questions were to be given by expressing approval or rejection in the four-step Likert scale (*I have never heard of them/ I've heard about them*, *but I don't know what they are/ not very familiar/ I am very familiar with them*; *yes/ no/ maybe/ I don't know* or *always/ usually/ seldom/ never*, etc.); (3) open questions. Respondents were asked to evaluate on a 5-point scale (*1- do not agree at all, 5 – totally agree*) the challenges they face in implementing sustainable development goals in their course or program as well as competencies to be improved. The questionnaire (in Latvian) is available at: https://www.iipc.lv/surv/index.php/343144/lang-lv.

333 academic staff members from different engineering higher education institutions in Latvia participated in the survey, but only 60 questionnaires were fully completed, which is also taken as a basis for this study. Therefore, it should be noted that this was a case study and it only reflects the views of those who participated in the survey. The characteristics of the research sample are given Table 1.

Table 1. Characteristics of the Research Sample (N = 60).

Quality	Category	Percent (%)
Gender	Female	65.00
	Male	35.00
Education	Professional education	21.67
	Bachelor's Degree	18.33
	Master's Degree	30.00
	Doctor of sciences	30.00
Age	18–30	13.33
	31–40	21.67
	41–50	23.33
	50–60	26.67
	60+	15.00

4 Research Results

The results of the study show that only a few engineering higher education institutions in Latvia have developed a specific action plan to integrate sustainable development goals and environmental issues into engineering education curricula. In all higher education institutions, the main activities included in this document are the results to be achieved by the study programs to ensure a sustainable future as well as measures to ensure quality education. In some cases, the action plan for integrating sustainable development goals and environmental considerations into engineering programs includes the development of new special and compulsory study courses, such as sustainable farming, as well as transforming study courses on a problem-solving approach by choosing one of sustainable development or environmental issues. In Latvia, there are also engineering higher education institutions in which eco-councils have been established and the green direction of the student association has been determined. In other cases, activities focus on responsible daily behavior in the educational institution, such as saving water resources, sorting waste, increasing energy efficiency, etc.

When asked how the SDGs and environmental education are implemented in the respondents' higher education institutions of engineering, 19.05% of the academic staff answered that these topics are included in the existing subjects and courses, 28.57% claimed that new specific subjects and/or courses have been developed, but 9.52% pointed that these topics are not addressed in their education institutions. 42.86% of respondents indicated the answer "other", explaining that either they are not familiar with the study programs and the courses offered by the university or named activities that would promote both the implementation of sustainable development goals and environmental education in their educational institutions, such as increasing the number of qualified teachers, implementing international cooperation measures for teacher training, etc. Some respondents assume that their higher education institution has study programs that are thematically related to sustainable development or environmental issues, however, they indicated that there is no mandatory instruction to pay attention to these issues in all study programs and courses of their higher education institution.

The results of the survey show, that only 23.33% of the surveyed academic staff very familiar with SDGs, while 16.67% - not very familiar. Although 31.57% of them have heard, they do not know who they are, but a fifth of respondents have never heard of them. Respondents were asked to name three SDGs. The most commonly mentioned activities that meet the SDGs are: protecting the planet, managing climate change, conserving / protecting life on earth, responsible consumption, reducing inequality, eradicating poverty, sustainable cities and communities, using renewable energy, health, etc. Some academic staff members were also able to name more specific tasks stemming from the SDGs: to provide inclusive and quality education and to promote lifelong learning opportunities; to promote sustainable, inclusive and sustainable economic growth; to ensure access to water and sanitation for all and sustainable management, as well as human survival through cooperation.

The engineering academic staff was also asked to rate their skills, knowledge and competence for the implementation of SDGs in the learning process according to the 4-point Likert scale (yes, no, maybe, I don't know). As seen in Table 2, more than one fifth of respondents (23.33%) follow the trends of education on sustainable development, while 25% no. 21.67% of engineering academic staff think that they have ecological intelligence, although 28.33% in doubts about it. Unfortunately, only one sixth (16.67%) of surveyed academic staff have sufficient competencies to provide information on SDGs and include them in their study courses and 23.33% don't have knowledge about SDG's implementation.

Table 2. Self-assessment of skills, knowledge and competence of engineering academic staff.

Statement	Yes (%)	No (%)	Maybe (%)	I don't know (%)	No answer (%)
Do you follow education on sustainable development?	23.33	25.00	16.67	15.00	20.00
Do you have ecological intelligence?	21.67	16.67	28.33	28.33	15.00
Do you have knowledge about SDG's implementation?	20.00	23.33	18.33	20.00	18.33
Do you have skills to facilitate dialogue on sustainable attitude for environment with students and colleagues?	21.67	18.33	23.33	16.67	20.00
Do you have sufficient competencies to provide information on SDGs and include them in your study course?	16.67	20.00	25.00	18.33	20.00

Engineering academic staff were asked which SDGs are included in their course, program or daily work (Table 3). The greatest attention in engineering studies in Latvia is paid to the SDG No 4 "Quality education" - 38.33% of respondents claimed that this goal is included in their courses, programs and daily work, but 18.33% plan to do it. The second most important goal is No 9 "Industry, Innovation and Infrastructure". About one third of surveyed engineering academic staff have included in their courses, programs and daily work also other SDGs: "Partnerships to achieve the Goal", "Good Health and Well-being" and "Gender Equality".

Table 3. Inclusion of SDGs in study courses, programs or daily work.

Statement	Yes (%)	No (%)	I plan to include (%)	No answer (%)
GOAL 1: No Poverty	20.00	28.33	18.33	33.33
GOAL 2: Zero Hunger	21.67	30.00	18.33	3.33
GOAL 3: Good Health and Well-being	30.00	18.33	21.67	30.00
GOAL 4: Quality Education	38.33	16.67	18.33	26.67
GOAL 5: Gender Equality	30.00	20.00	21.67	28.33
GOAL 6: Clean Water and Sanitation	25.00	23.33	20.00	31.67
GOAL 7: Affordable and Clean Energy	28.33	21.67	21.67	28.33
GOAL 8: Decent Work and Economic Growth	28.33	20.00	20.00	31.67
GOAL 9: Industry, Innovation and Infrastructure	33.33	21.67	20.00	25.00
GOAL 10: Reduced Inequality	23.33	21.67	23.33	31.67
GOAL 11: Sustainable Cities and Communities	23.33	26.67	23.33	26.67
GOAL 12: Responsible Consumption and Production	23.33	21.67	23.33	31.67
GOAL 13: Climate Action	26.67	21.67	23.33	28.33
GOAL 14: Life Below Water	25.00	21.67	20.00	33.33
GOAL 15: Life on Land	26.67	21.67	23.33	28.33
GOAL 16: Peace and Justice Strong Institutions	25.00	25.00	20.00	30.00
GOAL 17: Partnerships to achieve the Goal	31.67	20.00	23.33	25.00

The results of the research show that 30% of the surveyed engineering academic staff members have covered the topic of sustainability in their study materials, but 18.33% could not provide an answer to this question. Some teachers question whether sustainable development goals can be included in any course of study. It is also worth mentioning an answer about the subject - mathematics. The respondent says that mathematics begins when a number as a concept is abstracted from countable objects. Therefore, the respondent believes that mathematics as a subject is not the right place to discuss the environment, climate change, etc.

Academic staff were invited to name at least three different teaching methods/pedagogical approaches that promote awareness and change attitudes towards a responsible future. Behaviorism, pragmatism, humanism and constructivism are offered as basic approaches, all of which can both promote understanding and change attitudes. Responses also include student self-directed studies, purposeful positivism, communication, dialogue and open conversation, listening to opinions, practical examples and actions, experiments and research that contribute to all knowledge and understanding, the academic staff personal example - actions, respect for people (nature, country, society), co-operation (real co-operation, not "working together", but common goal awareness, co-ordination of resources and analysis of results after the co-operation process) at all levels - with students, colleagues, administration, society.

Respondents were asked to rate on a 5-point scale (1 - strongly disagree, 5 - strongly agree) the knowledge, skills and competencies required to implement sustainable development goals in their course or program (see Fig. 3).

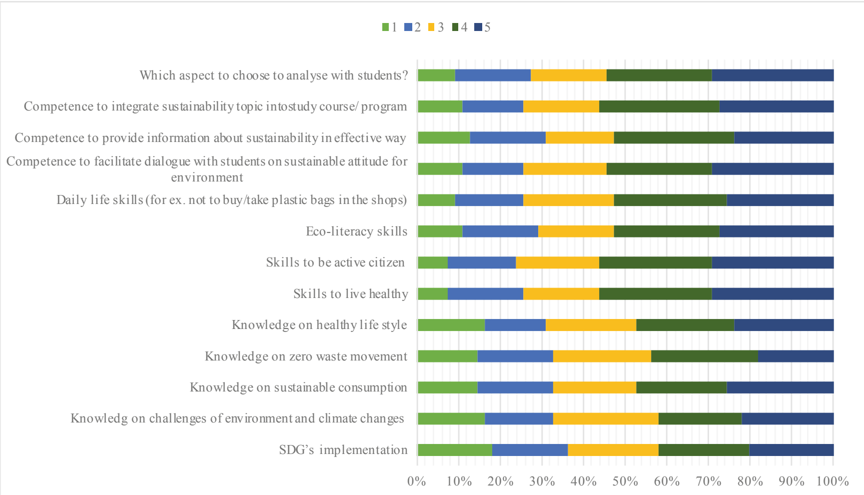

Fig. 3. Knowledge, skills and competencies required for the implementation of SDGs in engineering study programs or separate courses.

The results of the research show that 56% of engineering academic staff need to develop the skills to actively participate in citizenship and live a healthy life as well as to improve professional competence how to integrate sustainability topic into study programs. 54% of respondents face the challenge of choosing which sustainability aspect to analyze with students. Knowledge about SDGs implementation as well as challenges of environment and climate changes is less important for engineering academic staff - only 42% of respondents agree or strongly agree.

5 Conclusions

The results of the survey show that a relatively small proportion of respondents (23.33%) are very familiar with the SDGs, but it is regrettable that some have not even heard of SDGs (20% of respondents).

Engineering academic staff were also asked how SDGs and environmental issues are implemented in their university. In some cases, SDG and environmental themes integrated into all professional subjects and courses (19.05%), in some - provided new specific subject or course (28.57%), but 9.52% of respondents claimed that nothing is done in this direction. According to the survey results, only some universities have specific activities for educators related to implementing sustainability and SD goals into higher engineering education.

When it comes to the competencies that engineering academic staff needs to develop to implement the SDGs in engineering study programs or separate courses, it should be noted that almost all the competencies, skills and knowledge mentioned in the questionnaire are equally important for engineering academic staff.

The study mainly uses the self-assessment method, so the results were based on the opinion of the respondents and therefore the results cannot be generalized, but can be used to identify problems and identify future actions or research directions.

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Improvement of STEM Higher Education in Hungary

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Abstract. At our university, we have recognized several problems according to SWOT analyses. Not enough number of students would like to select STEM faculties. The dropout ratio is too high in STEM area. Requests of Labour market have not appeared in the Training curricula. The candidate students don't know the future carrier and the content they have to learn. In secondary schools, the development of basic competencies and STEM subjects is not effective. The preparation for higher education is not enough, which leads to dropout by the end of the first year in higher education.

We proposed to adopt the elements of French Grandes Écoles for reforming Hungarian Engineering Education. What are the advantages of that system? There is a preparation phase after the final exam in secondary schools, where students receive an intensive STEM preparation for higher education. This elite engineering education focuses on societal recognition. They select the participants well, give intensive learning experience and reach high ranking prestige among engineers' jobs. We decided to elaborate a new educational model consisting of three parts. The first two semesters are for preparation. There are 6 semesters of Bachelor of Profession, and finally, 2 semesters for Master of Profession. This new system is not the reduction of BSc + MSC ones. We would like to educate candidates who can belong to the best prepared engineers, can give the right answers to the demands of Labour Market and are committed to society.

Keywords: Engineering education · STEM · Bachelor of Profession

1 Introduction

The lack of STEM (Science, Technology, Engineering, and Math) knowledge of engineers (see Fig. 1) is a big challenge not only in Europe but in Hungary as well. The STEM knowledge can be a comparative advantage in Labor Market. 'Highlights the fact that the EU faces a shortage of skills in science, technology, engineering and mathematics (STEM), while it has an over-supply of social science graduates; is of the opinion that supplementary initiatives at European and national level are necessary to respond to the bottlenecks in STEM-related jobs and studies; recommends that the Commission and the Member States take measures to enhance the attractiveness and value of STEM subjects and to encourage young people, including women, to take up STEM studies' [1].

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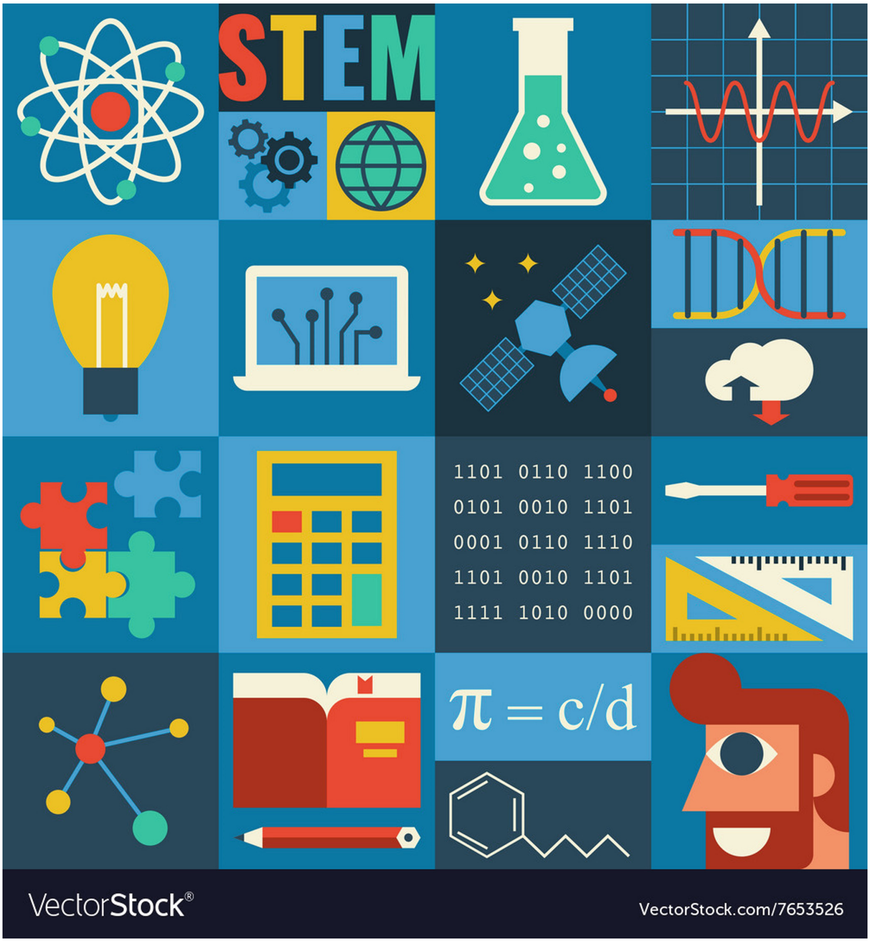

Fig. 1. STEM education

In the last few years in Hungary, in spite of governmental actions, supports of national and international projects the number of appliers to STEM engineer faculties of Technical Universities has not increased. According to the 2020 data of national authority, the number of enrolment has furtherly decreased because of the compulsory high level final exam introduced in secondary schools.

The World Economic Forum stated in the Agenda: 'Skills growing in prominence include analytical thinking and active learning as well as skills such as technology design, highlighting the growing demand for various forms of technology competency. However, proficiency in new technologies is only one part of the 2022 skills equation. "Human" skills such as creativity, originality and initiative, critical thinking, persuasion and negotiation will likewise retain or increase their value, as will attention to detail, resilience, flexibility and complex problem-solving' [2] (see Fig. 2).

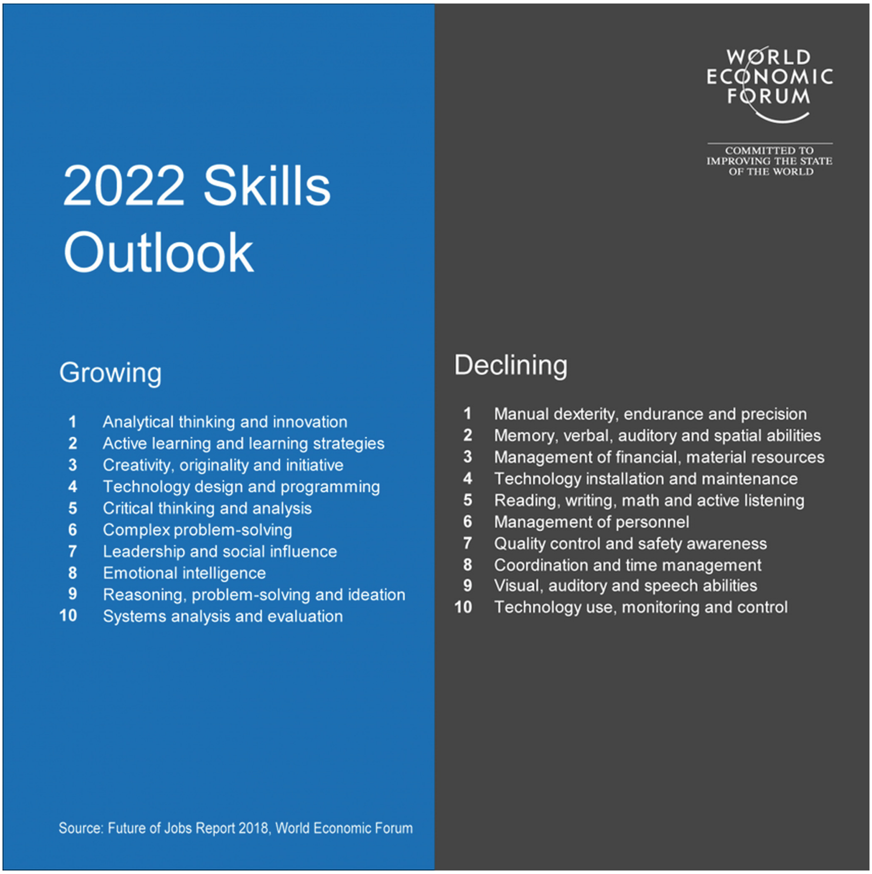

Fig. 2. Future of jobs

There are several requirements for qualified engineers: they have to be creative, critical thinking, complex program solvers, and have to have competencies of cognitive flexibility, high level communication, team works and application of foreign languages.

2 Background and Goal

At our university, we have recognized several problems according to SWOT analyses. Not enough number of students would like to select STEM faculties. The rate of early school leaving (ESL) is too high in STEM area. Requests of Labor market have not appeared in Training curricula. The candidate students don't know the future carrier and the content they have to learn. In secondary schools, the development of basic competencies and STEM subjects is not effective e.g. teaching Math is not practice oriented, this is why the results of students on PISA tests are weaker. The preparation for higher education is not enough, which leads to ESL by the end of the first year in higher education.

Based on analyses, the needs of technical higher education and industry are the following:

- Highly qualified pupils as an input from secondary schools with strong competencies of Math and basic STEM subjects for learning the engineering knowledge.
- Committed students who know well the selected profession and are able to meet the requirements.
- High quality STEM education with balanced theoretical bases and practice.
- Relevant knowledge of the Labor Market supported by the company practical training.
- Application of a foreign language at high level.
- Higher number of technical education with reducing the rate of early school leaving.

The national industry looks for qualified, talent labor force which has futureproof competencies. Because of this, it is strategically important to provide adequately prepared students as an input on STEM areas and improve the success of students. To solve these problems, the government made important steps. It is emphasized to make cooperation between public education and higher education. To bring closer the demands of industry to higher education, the dual higher education, where the scientific semesters and practical works in companies are alternating, is increased.

In the analyzing process, we could recognize two main problems. The knowledge level of students arriving from secondary education to higher education is not balanced and, in several cases, not enough. There are no possibilities to make up for the lacking basic and STEM knowledge and competences in higher education. Compared to secondary education, the requirements are growing dramatically in higher education, and students do not have the learning methodology technics that can overcome this problem. The other problem is that the identity to the selected profession has not evolved in secondary education by starting higher education, and the motivation is not enough when the rate of charging is increased.

We have to find the way to reform technical higher education and to give good answers to solve the recognized problems.

3 Methodology of Development

After analyzing the problem, the educational specialists studied some foreign good practices. They found an existing good model in France [3]. They proposed to adopt the elements of French Grandes Écoles for reforming Hungarian Engineering Education. What are the advantages of that system? There is a preparation phase after final exam in secondary schools, where students receive an intensive STEM preparation for higher education. This elite engineering education focuses on social recognition. They select the participants well, and at high level, give intensive learning experience and reach high ranking prestige of engineers' jobs. Our university decided to elaborate a new educational model consisting of three parts. The first two semesters are the preparation phase. There are 6 semesters of Bachelor of Profession (Bprof), and finally, 2 semesters for Master of Profession (MProf). This new system is not the reduction of traditional BSc and MSc study. Our university would like to educate the best candidates, who can belong to the best prepared engineers, can give the right answers to the demands of Labor Market and are committed to society.

In the 2020–2021 educational year at our university at the Electrical Engineering Faculty, we are going to start a pilot training to establish this new educational model consisting of three parts. The first part is the two-semester preparation.

Last year, the legal background changed in secondary vocational education. We have a new Vocational Education Law. It contains several changes compared to the previous educational system. The secondary school system has changed, we have again a five grade vocational school where technicians are prepared. Five years ago, the organizations of secondary vocational schools have changed. 44 Vocational Training Centers were established, which contain 8–15 previous independent secondary vocational schools. Since last year, the professional leading of higher education and vocational secondary education has belonged to the Ministry for Innovation and Technology. This legal and professional background supported us to create partnership with three Vocational Training Centers to elaborate commonly the first two semesters for preparation of 6 semesters of Bachelor of Profession.

According to the problems recognized before, there is a big gap between secondary vocational education and technical higher education (see Fig. 3).

Fig. 3. Bridge over gap

We can increase the success of STEM engineering education if we build a bridge over the gap between the secondary vocational education and technical higher education. The pupils in secondary vocational school receive a guide experienced in the bridge, who can help them with acclimatization of being a student in technical higher education. This support encourages them to climb to the peak to reach the diploma and avoid the ESL.

In the first year, we plan a general preparation for engineering education, based on enforcement of competencies of Math and Physics, learning of general basic engineering knowledge and programming in Informatics. Furthermore, there will be two other tasks of preparation: To teach a foreign language in a high number of lessons to prepare them for professional literacy in English, and mobility abroad, learning and working in international teams. There will be some learning methodology practice led by professional trainers to teach them how to learn in higher education and solve the problem of increased rate of charging. This preparation year will be implemented together with educators of higher education and teachers of secondary vocational schools (see Fig. 4).

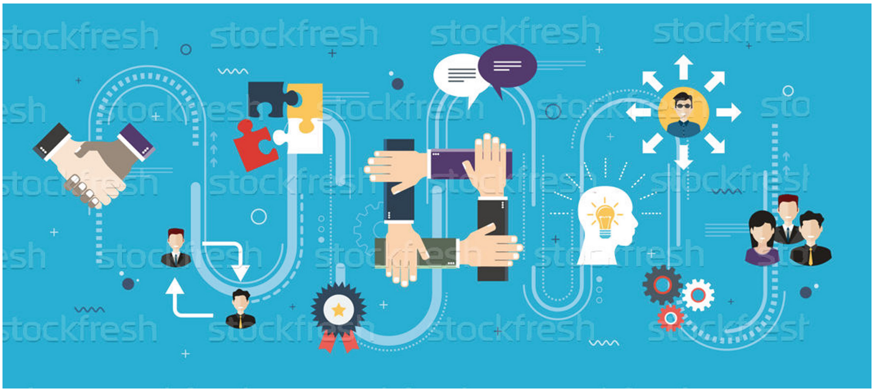

Fig. 4. Cooperation between university and vocational training centers

For the following 6 semesters, we are going to introduce only the main modules yearly. In the first year, students are to learn theory and application of Math, engineering Physics, basics of Economy, Management and Informatics. The professional foreign language learning, basically English, will be still in focus and practical training will be started.

In the second year, the education will focus on theoretical multidisciplinary STEM and natural science subjects, and students will be able to select special ones according to their professional area. Besides technical subjects, they are to learn legal, economic, social and human subjects as well. They will start their team works to elaborate research, development or innovation projects supported by university institutes. The second year will be finished with a 3-month national or international company practice.

In the third year, according to the BProf faculty, students will learn the advanced professional subjects and select a special professional area. They will implement a

5-month research practice in a state or private research or development company or institute. They will write their thesis in connection with the company or research practice.

The Master of Profession (Mprof) will be 2 semesters. Those students who finished the Bprof study can apply for Mprof education. The preparation and intensive theoretical and practical training give a good background for absolving a two semester Master education. It was important to study the good practice of the elite universities in the United States, how they manage the one year master of engineering education. 'The Master of Engineering (MEng) program at UC Berkeley combines a breadth of topics in business and engineering management, applying them to a depth of study in your technical concentration' [4]. Objective of MProf education is to prepare engineer leaders, to give them special knowledge of profession, management-leadership and high level communication. MProf is planned as a project based dual engineering education established on cooperation with national or international companies and small or medium entrepreneurs to implement the students' previous theoretical studies in high level practical circumstances. In the development process, we studied several national and international sources of literature [5–10] and the experience was built into the development of Curricula.

4 Results and Conclusions

Our educational reform will change the engineering education. We try to support engineering education strengthening the STEM knowledge, with a strong selection process, but creating a one-year preparation, which will reduce the ESL. The graduated engineers will have experience and knowledge in accordance with the demand of the Labor Market. They will be able to develop competencies of creativity, critical thinking, complex program solving, cognitive flexibility, high level communication, team works and application of foreign languages.

Curricula of Master of Profession education will be developed after one year, based on the experience of Bachelor Professional first two semesters. It will be announced for the active BProf students later.

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Distant Education of Mature Age Students – Motivational Aspects

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Abstract. The aim of our paper is to share our experience with fostering motivation of mature students to develop new competences to use technology in learning. For some mature age students, technology may be another source of anxiety, because they do not have sufficient previous experience in this respect. This is the reason why, an important role for a teacher of mature age learners is that of preparing them to use the technology in a non-threatening context meant to build positive attitudes in adults towards both technology and learning. Our pilot study refers to the changes of attitudes adult learners might have experienced when their fears to use technology had been reduced.

Keywords: ICT · Mature age students · Motivation · Learning · Teaching methodology

1 Introduction

Unlike younger learners, the adults almost always have a sound reason why they are studying (Bilčík et al. 2019), and that reason will be their primary motivation (Merriam et al. 2007). Perceiving education as a way to improve their self-image and reach various personal goals (Hargaš 2019), adult learners are usually highly motivated from the very beginning of the instruction process, and this makes it much easier for the teacher to perform his/her role as a motivator. Harmer (2007) points out, "many adults are able to sustain a level of motivation by holding on to a distant goal in a way that teenagers find more difficult" (p. 84).

Adults are certainly more cooperative learners, and, what is more important, their cooperation comes as a natural consequence of their seeing the point of various instructional situations in which they are involved (Wahl et al. 2019). There are also situations when students generally have more learning experience behind them, but this aspect can prove to be both beneficial and problematic (Orvis 2018). They have certain expectations about the learning process, and, in case these expectations are not met, learners may become critical towards the new context of instruction. Thus, on the one hand, adult students have built well-developed learning strategies that had previously served them well in other settings (in other schooling), and the teacher could help them use these strategies to their advantage. On the other hand, adults are less confident in

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their intellectual abilities, and this might make them anxious about learning (Dobrovská and Andres 2016). In relation to the anxieties, insecurities, and fears of the adults who return to school, the adult educator Stephen Brookfield (2005) discussed the term "impostor syndrome", denoting a collection of feelings of inadequacy, of chronic self-doubt which make people think that their accomplishments are nowhere near as good as those of the people around them.

Modern trends in education are characterized by an overall shift towards the use of digital technologies especially when regular in class teaching cannot be applied for some reason - this has recently occurred during the corona virus quarantine at many European universities. Technological innovation extends learning opportunities depending on the efficient use of the learning environment with an emphasis on e-learning, m-learning, MOOC, social networking, educasting, shared e-learning support through cloud computing services.

2 Methodology

The aim of our study was to implement new teaching methods into a study program of mature students during corona virus quarantine in March, 2020 and to analyze their reactions and attitudes in new situation. Our questions were: what is the level of entrance ICT knowledge of our students, are they ready to use technologies to improve learning, are teachers of mature students ready to prepare webinars in a form which may encourage students to do so and is there any attitude change after student experience with Microsoft Teams.

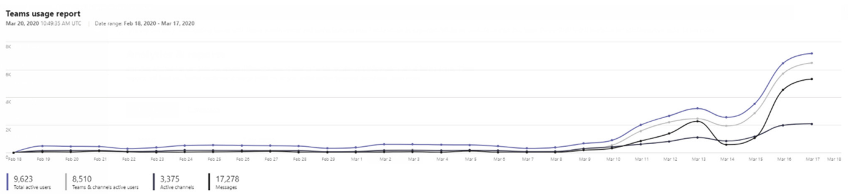

Fig. 1. Starting curve of transition to distance form of education

In Fig. 1 abrupt growth of distant electronic forms of teaching during corona virus quarantine is displayed. The CTU in Prague had to react within few days to a new situation.

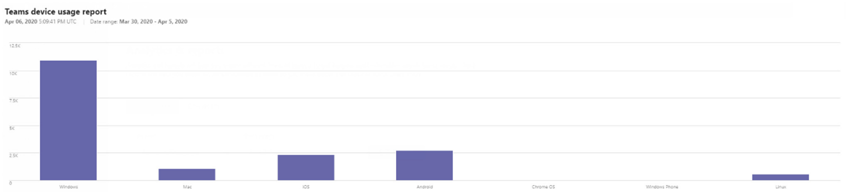

Fig. 2. Windows operating system dominates among devices used for access to MS teams

As displayed in Fig. 2, within a short period of time academic staff was able to adapt to new conditions and set up distance learning using Microsoft Office 365/Microsoft Teams. Cloud services were deployed on a global scale and encouraged communication during pandemic, in terms of management level, as well as for educational purposes, organizing lectures, exercises and seminars. Starting from March 10, 2020, so-called non-contact teaching methodology was introduced at the CTU in Prague, full deployment started on March 16, 2020, with 2,255 Teams established during first ten days. Computing and Information Centre opened up and filled these Teams approximately with 900 students and teachers on the basis of data available (identities) in the study information system. By 18 March 2020, approximately 50 Teams had been formed from two or more subjects (by merging), roughly 50 Teams were created according to timetable sheets (by splitting).

After webinars and workshop had been delivered to students a feedback was required from them: it was based on a questionnaire with open-ended questions. We asked mature age students to indicate their feelings and opinions on electronic support they had received. A sample of 124 mature age students of the study program "technical teacher education", aged 29–45, gave the feedback. The aim was to maintain maximum variation across a wide range of variables - age, gender, ability to comprehend and deal with assessment requirements. The items of the questionnaire focused to the self-confidence, motivation increase and assessment of the e-material distributed to them. More than half of the students declared their knowledge, competence and skills increased considerably or to some extent, 20% believed their knowledge did not change and the rest could not answer the question. More than 84% of answers indicated the growth of motivation to use electronic devices for study purposes. 90% of students appreciated appropriate reaction of teaching staff to encourage their motivation and to support their ICT knowledge.

3 Results and Discussion

The items of our questionnaire related to:

- Previous experience with e-learning, especially with Microsoft Teams. Students were asked to assess their entrance technology knowledge on the scale 1–7 (1 being no experience, 7 advanced technology knowledge)
- Previous motivation and readiness to use technology for study reasons
- Disruptions in learning how to use new technology (anxiety, fear, other negative emotions)
- Perceived quality of webinars and workshop (specially user friendliness and intelligibility)
- Attitude changes after 2 weeks' contact with online learning
- Readiness to re-use technology in future learning.

3.1 Previous Experience with E-Learning and Microsoft Teams Platform

We anticipated student higher early experience with other forms of e-learning than with MS Teams. This assumption was confirmed. Students mostly declared low or moderate experience with e-learning, most of them assessed their knowledge between 2–4, less than 5 per cent believed to be fully familiar with it. But almost 90% confirmed no previous experience with Microsoft teams (Table 1).

Table 1. (a) Previous experience with e-learning (124 students), (b) Previous experience with MS teams

(a)

Knowledge	1	2	3	4	5	6	7
Students	2	13	31	32	16	18	6
%	1,6	10,45	25	25,8	13	14,5	4,8

(b)

Knowledge	No knowledge	Moderate knowledge	Advanced knowledge
Students	108	10	6
%	87,1	8,1	4,8

3.2 Previous Motivation and Readiness to Use Technology for Study

Our expectations about previous mature student readiness to use technology for study purpose was to be mostly low or moderate. But almost 20% expressed no motivation at all. In additional answers, students explained they had been used to traditional ways of learning and teaching and planned no changes in this respect (Table 2).

Table 2. Previous motivation and readiness to use technology for study

Previous motivation	None	Low	Moderate	High
Students	24	36	44	20
%	19,3	29	35,5	16

3.3 Disruptions in Learning How to Use New Technology (Anxiety, Fear)

Possible disruptions were declared by half of mature student group. Additional student comments underlined necessity of using a small range of technologies being used for a wide range of tasks to reduce anxiety from learning too many technologies which were not universally successful in terms of usage and adoption (Table 3).

Table 3. Disruptions in learning how to use new technology (anxiety, fear)

Disruptions (fear, anxiety)	None	Low	Moderate	High
Students	19	45	36	24
%	15,3	36,3	29	21

3.4 Perceived Quality of Webinars and Workshop (User Friendliness)

Mature students appreciated improved access to information in an intuitive way. In their opinions, webinars made a flexible learning experience thanks to the time convenience they yielded (Table 4).

Table 4. Perceived quality of webinars and workshop (user friendliness) (1 = lowest, 7 = highest)

Perceived quality	1	2	3	4	5	6	7
Students	0	0	6	7	43	58	10
%	0	0	4,8	5,6	34,7	46,7	8

3.5 Attitude Changes of Mature Students

More than half of the students declared their knowledge, competence and skills increased considerably or to some extent, 20% believed their knowledge did not change and the rest could not answer the question. More than 84% of answers indicated the growth of motivation to use electronic devices for study purposes. 90% of students appreciated appropriate reaction of teaching staff to encourage their motivation and to support their ICT knowledge (Table 5).

Table 5. Attitude changes after 2 weeks' contact with online learning - readiness to re-use technology in future learning

Motivation after experience	None	Low	Moderate	High
Students	13	36	47	28
%	10,5	29	38	22,6

4 Conclusions

The online classroom for mature age students is different enough from the traditional one. Faculty members need to create contents for digital delivery that are substantially different from those they teach on campus. Teaching online requires an even keener focus on mature student engagement than the face-to-face model does.

To engage mature students who are not in the room during a lesson, the course should mix spurts of discussions, collaboration, video and audio clips, and hands-on exercises with text and possibly brief video lectures. Long lectures probably aren't the best way to engage a face-to-face class – and might be even more ineffective online. Presenting information in 10-minute "chunks" and varying the format in an easy way would be another suggestion.

The question of how to explore and support the development of mature age students' motivation to use e-technologies for study purpose is far from simple. Since adults frequently feel rather insecure in their position as students, teachers should provide support and encouragement when asking them to take risks or try new skills. The teacher should be focusing on the positive emotional aspects of learning process and on the progress that mature age learners are making.

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Promoting Creativity of Engineering Students in the Foreign Language Classroom

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Abstract. The article focuses on the issue of promoting the creative abilities of Food Science majors through the Foreign (English) language course. English language course is one of the non-core academic disciplines which provides plenty of educational opportunities for future engineers to stimulate their creative abilities. Study of the theory and practice behind engineering education and foreign language teaching helped to identify the following gap: the need for promoting the creativity of engineering students through non-core academic disciplines and insufficient attention for its implementation through the English language course. In the process of bridging this gap, a key research question arose: how to encourage professional creativity of engineering students in the English language classroom? The purpose of the article is to study and identify the most versatile and effective learning techniques and strategies promoting creative abilities for Food Science majors. Teaching experience in various universities helped to identify the following effective learning strategies and techniques: the method of interdisciplinary projects, business games, presentations, the interdisciplinary case-study method, and authentic texts. All of these strategies are versatile and can be easily used through the English language course to develop a creative component of professional competence for future engineers.

Keywords: Creative abilities · Foreign language course · Food science majors

1 Introduction

Currently, in our society, new ideas and innovations play a crucial role in its development [1, 2]. Creativity has become a constant practice and a major source of a competitive community. In almost any field of production, the winner is ultimately the one who has the creative abilities [1].

Today, the priorities of modern higher education include mobility [3–8, 22, 23], proficiency, personal development skills, intellectual potential, and professional qualities. The main strategy of universities is the transition from reproductive to creative education [1].

Creative education is strengthening its position as an innovative type of education, focusing on promoting creative thinking, nurturing creative abilities and intellectual potential, and the search for new approaches responding to current challenges [1].

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In our research, we focused on the process of enhancing the creative education of engineering majors. At universities, students acquire professional knowledge but are not deeply aware of solving engineering problems and creative tasks. Special attention should be paid to promoting their creativity and imagination, since today a new style of engineering thinking is required aimed at creating new equipment and modern technologies [9]. Creative engineering thinking is characterized by a high degree of freedom and a large number of proposed solutions. From an innumerable number of combinations, due to advanced analytical abilities engineers can choose the necessary option. Creativity for an engineer is closely related to the activity. "Creativity" is a personality-oriented and activity-based approach to learning, it can be considered that creativity is an independent activity of the student, leading to the development of a new level of knowledge or abilities [9].

The creativity of future engineers should be nurtured at all stages and through all disciplines as well as non-core academic disciplines.

The English language course is one of the non-core academic disciplines that unlocks students' creative abilities [12, 13]. Studying the creative abilities of students and the influence of English language on the development of students' creativity is very relevant and some researchers provide a detailed analysis of the benefits of this course for fostering students' creative spirit since it has the considerable educational potential [13].

First of all, the English language course helps to acquire knowledge in different areas of life, science, and art.

Through the English language course, engineering students broaden and increase their knowledge and ideas they have received through other academic subjects [14]. However, it can be implemented only when students are ready to expand their general outlook, develop their way of thinking, memory, feelings, and emotions.

The English language course compared to other courses includes a small number of students in a group, focusing on interpersonal communication, personality-oriented and activity-oriented tasks, etc. Personality-centered techniques in teaching a foreign language considerably contribute to nurturing the creativity of students.

Despite a large number of articles that have been published recently, they do not provide sufficient guidance materials to instructors on how to nurture creativity for engineering students through English language.

The study of the theory and practice behind engineering education and foreign language teaching helped to identify the following gap: the need for promoting the creativity of engineering students and insufficient attention for its implementation through Foreign language.

In the process of bridging this gap, a key research question arose: how to stimulate the professional creativity of engineering students in the Foreign language classroom?

For this purpose, the appropriate learning environment, methodology, creative approaches, interactive learning, and teaching strategies should be developed.

Thus the objective of the article is to study and determine the most versatile and effective learning and teaching techniques and strategies promoting creative abilities for Food Science majors through the English language course using teaching experience of the core disciplines and foreign language instructors.

2 Methods and Techniques for the Development of Creative Abilities of Food Science Majors through Foreign Language

In creative education, action learning is the most comprehensive and effective method, which is carried out through problem-solving, analyzing, and playing out real-life situations, team-work, and independent activities. Action learning is integrated into fundamental, high-tech, advanced, personal, project-based education, increasing the research and innovative potential of the engineer [1].

The analysis of the research literature, international practical experience and our personal experience of teaching English for engineering students at Kazan National Research Technological University, as well as empirical research methods, such as observation and analysis of various creative activities used in the English language classroom, allowed us to identify the most effective and versatile learning strategies and techniques promoting creative abilities of Food Science majors through Foreign language course. The findings of the analysis are as follows.

2.1 Interdisciplinary Projects

When it comes to the development of the creative abilities of engineering students the project-based learning is of considerable practical importance and has several benefits. Project-based learning develops independent thinking and is more focused on the students themselves. Project-based learning stimulates educational motivation and encourages creativity as well. Due to project-based learning, students see their work as personally significant, consequently enhancing their professional and creative abilities. This method always assumes problem-solving, which involves, on the one hand, the use of a variety of teaching methods and techniques, and on the other hand integrates knowledge and skills from various fields of science, engineering, and creativity. When using this method, it is extremely important to arouse interest in the students. It can be done through real-life and professional issues, familiar and meaningful to students. Students can work on their projects independently, in small groups, or as a whole group. Creative abilities are better developed when students work in small groups. In a team, students can gain practical experience, since they learn to distribute responsibilities, become confident in working with others and express their preferences. Due to its versatility, it can be used for teaching any discipline. A particular quality of project-based learning is the interdisciplinary character of this method. In our work with Food Science majors, we use the experience of the core discipline instructors, so in that way, we foster professional creative abilities of Food Science majors.

2.2 Business Games

Effective assistance in activating the creative abilities of Food Science majors is provided by business games. Business games are a very promising teaching strategy, as it contributes to the creation of a favorable psychological climate in the classroom; increases motivation and activates learning and cognitive skills of future engineers;

makes it possible to use existing knowledge, personal experience, and communication skills in various situations. This method is based on real-life situations related to the students' future occupation and can be directly used in the English language classroom. The use of business games contributes to the development of professional competences of future engineers [19]. This method takes into account the individual characteristics of each participant of the game due to joint practice activities and the ability to use existing knowledge. We use the following business games for Food Science majors as:

- launching startups in the food industry;
- food procurement for public catering enterprises;
- panel discussion "Food additives and a healthy lifestyle";
- new products development;
- quality control of the sausage production process, dairy and bakery products, etc.

Thus, according to our personal experience, we can state with confidence that the use of these business games enhances the effectiveness of teaching Food Science majors, develops their creative thinking, and keeps them motivated.

2.3 Presentations

The presentation comprises another effective and versatile technique that can be used to foster the professional creativity of Food Science majors through Foreign language.

Presentations are an integral part of almost any professional activity, including the professional activities of engineers and they encourage the creativity of engineering students, which implies a well-developed imagination, quick reaction, as well as expertise, flexibility, and critical thinking [15].

Presentations can either be a separate task or a part of other tasks. During the preparation process, students conduct research, study the topic of the presentation, and present the findings of their work.

In terms of teaching Food Science majors the junior students who don't have profound professional skills can be asked to present national cuisines and national eating habits, cultural similarities, and differences in food traditions, healthy cooking methods, organic food manufacturing, challenges related to food manufacturing. Senior students can report on new technologies and processes, food ingredients manufacturing, food processing industry issues, and solutions to major challenges in the food industry.

2.4 The Interdisciplinary Case-Study Method

The next strategy involves case studying. Case technologies meet almost all the requirements for the teaching-learning process and can serve as one of the key methods for fostering creativity among Engineering students [16]. Cases present practical and theoretical information about current events and issues, which increase students' interest in learning, contribute to the active acquisition of knowledge and skills. A case is an informative unit that offers insights into the situation and helps to make the right decision. Eventually, due to case technologies, students acquire practical knowledge and expand their professional skills [10]. Cases require considerable creative input from the instructor and students. The case must be adapted to fit students' levels [17]. The students are given a specific case to investigate and after establishing it they study the questions and report on them.

The example of one such case for Food Science and Technology undergraduate students is given below.

The case focuses on the development of a balanced seasonal menu for restaurants and cafes in response to a challenging issue of obesity. Obesity is widely spread in a modern society, which is caused by a metabolic disorder. One of the main reasons for it is fast food. Fast-food contains a lot of calories, an insufficient quantity of vitamins, and other harmful substances. To increase life quality and to promote a healthy lifestyle it is necessary to draw attention to food culture. The study of national cuisines makes it possible to draw up balanced everyday nutrition.

Tasks for students are to develop two recipes of national cuisine; compile job-order cards for these dishes; draw up a process chart of these recipes [18]. For the first-year students, only the first task can be used, as they are not yet familiar with some professional terms.

2.5 Authentic Texts and Extra Creative Activities

One of the important constituents of the creative component of engineers is motivation and its development becomes a priority task in engineering universities including Foreign language courses. Globally foreign language instructors, as well as instructors of the core disciplines, put a great emphasis on the motivation of engineering students. This becomes possible due to authentic texts as they increase motivation and interest in students. Reading tasks are designed to be highly motivating. They should be creative, novel, based on challenging and cognitive information. The highest criterion of motivation is the assessment of reading from a professional point of view, the recognition of foreign literature as an interesting, useful, and necessary source of information for future engineers. Thus, one of the urgent tasks for motivating engineering students through foreign languages is the issue regarding text selection [20]. As for Food Science students, texts, and articles on their major have great incentive potential. Besides, a large selection of inspiring stories of successful people in their field of engineering, new technologies are very relevant.

To promote creative thinking of Food Science majors, we also use some extra activities as situation modeling, creativity and imagination stimulating questions, etc. These types of tasks are presented below [21]:

- If you had to eat one thing and one thing only for the rest of your life what would it be?
- What is your favourite food?
- Imagine you are a chef, what type of restaurant would you open, and why?
- Imagine you work for an ice-cream company? What flavor would you invent and what creative name would you give to it?
- Describe what a day in the life of a pastry chef in Paris might be like.
- Write a short advertisement/commercial about Brussel sprouts. Remember, your job is to sell the vegetable!

- Write a funny and creative eulogy for the dinner you ate last night.
- Write a short story titled “The talking banana”.
- What kind of foods would be good to eat in space? Which foods would not be good or easy to eat in space?
- What is the one junk food you couldn’t live without? Explain why you love this food so much.
- If you were a drink/food/vegetable/fruit, which drink/food/vegetable/fruit would you be and why?
- Imagine some unusual pancakes. What makes them so unusual and how do you think they would taste?
- If you were a chef, what would be your signature dish, and why?

3 Conclusions

Currently, the issue of fostering creativity in engineering students has been gaining popularity, since the future of our society depends on talented people with critical thinking. Creativity is necessary for engineering students because new views and approaches are the driving force of progress. Improving the efficiency of activity in modern conditions depends on the fulfillment and development of the creative abilities of future experts.

Today, the competition is extremely fierce, that is why employers are looking for people who can think outside the box, are open to new ideas and approaches. Creativity becomes a real and urgent need for engineering development practice. To pursue this goal, it is necessary to provide a creative learning environment for developing creative attitudes among engineering students to their future occupation. Creativity, like any quality of character, can be developed and stimulated. It can be done through interactive methods aimed at developing creative thinking and professional interest.

It is necessary to develop and use interactive learning techniques and strategies [10, 11] that promote creativity in students and prepare them for innovative life in the new century.

The analysis of the teaching experience of university instructors and our personal experience of teaching English for Food Science majors at Kazan National Research Technological University enabled us to identify effective methods for nurturing the creative abilities of Food Science majors through foreign languages. Thus, the effective methods for developing the creative abilities of Food Science majors are the method of interdisciplinary projects, business games, presentations, the interdisciplinary case-study method, and the use of authentic texts. Almost all of the above-mentioned methods used by university instructors are versatile and can be easily applied in English language to develop the creative component of the professional competence of future engineers.

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The Challenge of Teaching Amidst COVID-19 in Brazil

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Abstract. This work is a portrait of online education provided to students during the pandemic of COVID-19 in Brazil. This aims to analyze the beginning of the change from presential classes to online classes. This work was completed in the first week of June, which according to the resources of epidemiology is before the peak of contamination. The educational year in Brazil starts between the end of February and the beginning of March, and presential classes were interrupted in the middle of March. With this situation, there was no time to plan how to develop the online classes and this should be solved while the online classes are developed. This work presents a survey answered only by teachers and professors that are teaching in online classes in Brazil. This research aims to highlight the difficulties, reality, and challenges faced by these education professionals, in a country with so many social differences.

Keywords: COVID-19 · Online Teaching · Challenges of Pandemic

1 Introduction

During 2020 the world faced the COVID-19 a pandemic that spread around the world forcing many countries to close any potential way of transmission. The first case of COVID-19 was identified in December 2019, in Wuhan City, and has since spread globally, resulting in the ongoing 2019–20 coronavirus pandemic [1]. COVID-19 is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The clinical spectrum of SARS-CoV-2 infection appears to be wide, encompassing asymptomatic infection, mild upper respiratory tract illness, and severe viral pneumonia with respiratory failure and even death, with many patients being hospitalized with pneumonia in Wuhan [2–4] and it soon became clear that efficient person-to-person transmission was occurring.

Many countries have decided to close schools, colleges, and universities to prevent students to get infected and to spread the disease in the population due to high transmissibility, even if the first information claims that the most affected are the oldest. This happened at the end of the semester in many countries of the North Hemisphere, which facilitated the cancellation of classes with no prejudice to students. The Brazil COVID-19 pandemic started on February 26, when a 61 years old man had tested positive in São Paulo [5]. Therefore, home confinement was initiated in the first half of

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March. But in Brazil, the first semester scholars start at the end of February or the beginning of March, which leads to the closure of the universities and schools with less than one month of classes.

Several studies [6–9] show different approaches and practices created to continue their academic lives normally, in an online way. However, many of these studies do not consider some facts that can decrease the efficiency of this novel educational reality, such as social inequality, professor and students' mental health [10], lack of devices for students and lack of teacher's skills to develop a class in a virtual environment. Besides that, some countries are having limited technologies and schools are not ready for the complete implementation of online education [11].

Thus, many institutions in Brazil had to adapt the way to provide their online classes during the pandemic. Several educational discussions about how to maintain the same instruction quality with a long-distance and how to create a virtual environment instantly, in a country that has so many social inequalities, were sparked. The transition to online mode has raised questions for the faculty about their capability to deal with the existing technology. Besides that, what to do in a house that has just one computer or laptop and now it is the only way for children, parents, and other relatives who have to work from home? However, some institutions started their activities not taking into account whether the student had or not devices to follow the classes.

With continental proportions, Brazil has several regions that have specific necessities and characteristics [12]. That implies in do not have an only way to teach and learn. Not to mention the existing social differences. For example, research of PNAD [13] shows that 43.4% of houses had a microcomputer and 93.7% had a mobile cellphone. However, only 74,9% access the internet through these devices for many reasons and we can mention that two of the reasons are: internet access service was too expensive (28.7%) and the internet service was not available in the house-hold area (7.5% of interviewed).

Another factor that can impair learning is that 6 or more people are living in the same house in 15,1% of residences and there are more than 3 residents per dorm in 40% of the houses [13]. For these reasons, we observe the necessity for studying how the practices of online education are being developed during the pandemic in Brazil and to empathize difficulties faced by professors and students. This work was finished in the first week of June 2020, where according to epidemiology is before the maximum of the contagion of COVID-19, and aims to be a portrait of the initial understanding and actions to this pandemic in Brazil. This paper studies the challenges of Brazil and its population to continue the education process at the schools in the online form of distance learning.

2 Educational System in Brazil

To understand the challenge to provide online courses in Brazil, during the pandemic, is necessary to understand some characteristics of the country. The area of the country is 8,5 million square kilometers being the fifth-largest country by area. The population is 190 million, that are irregularly distributed, with the majority living in large urban centers. Besides that, in part of the north region of the country is located the Amazon forest [14]. Figure 1 shows the map of the Brazil regions. With Table 1 and Fig. 1 it is possible to see that the regions have different areas and the distribution of the populations is extremely irregular. Therefore, many cities are only accessible by a river in travels that can take hours or days, in the north region.

Fig. 1. Regions of Brazil.

Table 1. Area and population of Brazil

Region	Area (kilometers)	Population	Population/Area
Southeast	924,608	80,364,410	86.92
Northeast	1,554,291	53,081,950	34.15
South	576,783	27,300,000	47.33
North	3,853,840	15,864,454	4.12
Midwest	1,606,234	14,000,000	8.72

The main educational system in Brazil for K-12 is the public system that should attend all students. The main educational methodologies are: the traditional classroom education, where books, blackboards are used by the teacher as a teaching aid, and; modern classroom education, where the classrooms are equipped with whiteboards, projectors, or audio-visual displays equipment and digital boards. Most of the public schools apply the traditional classroom. Usually, there are 35 to 40 students and 1 teacher per class. The public K-12 educational institutions attend the students with smaller familiar income, where many students do not have a computer or tablet to attend classes and have more limited access to the internet.

The universities are present in every state with at least one Federal institution and most of them have at least one State institution. Private institutions are also present, mainly in bigger cities and in greater quantity. In 2017, Brazil has 296 public universities/institutes and 2.152 private universities. Usually, there are 35 to 40 students and 1 teacher per class [15].

3 Methodology

Several of the approaches existent in a literature review could not be applied in this study due to safety standards suggested by the World Health Organization (WHO). Therefore, we decided to apply a survey only for teachers that were teaching throughout the pandemic. It is important to highlight that some public institutions in the elementary, middle, high school, and universities opted to not continue their classes due to all problems previously mentioned. Each State could realize your real situation and decide if they continue or not.

This survey was created in the Google Form platform and shared in social media like Facebook, Instagram, and forwarded through the WhatsApp messaging app. Because of the largest network in these media, we could achieve several people that could answer it without being identified. We shared in teachers, professors, universities, and different cities groups. Also, we had shared through known people who were interested to respond and helped to get more answers.

The survey intention is to raise data of the change between traditional and online classes that professors had to make and if the institutions that they belong provided the necessary support and infrastructure for this new challenge. Besides that, we asked if the students had conditions to follow this online education. For that, we create objective and multiple-choice questions with simple queries about the situation the interviewee was involved with. All information about this survey and all relational queries are described in the section and subsections that follow.

4 The Survey

The survey is a short questionnaire with only ten questions that should be answered only by educators that are working with online classes during the pandemic of COVID-19. Seven of these questions are multiple-choice and the three remaining are open-ended questions. There are 168 responses from different regions of the country and segments of the educational system. The next subsections are the ten questions and the responses.

4.1 City and State

The first question is about the city and region where the educator works, this is an open question because responders can work in more than one city and even in more than one state because they can work in nearby cities that are located in different states. As was discussed in the introduction of this paper, the epicenter of the COVID-19 was the state of São Paulo, in the Southwest region. Other local epicenters were Pernambuco, in the Northeast region and the city of Manaus, in Amazonas state, located in the North region.

The respondents are: 14 from the North region, 18 from the Northeast, 136 from the Southeast, 1 from the Midwest, and 1 from the South. From these respondents, 111 work in the capital of his state and the remaining 57 in cities far from these capitals and even in rural areas.

4.2 Educational System

The second question is about the public/private system where educators teach. The educators that responded to this survey work in: 107 (63.7%) only in public institutions, 42 (25%) only in private institutions, and 19 (11.3%) in both. The presence of 61 (36.3%) educators that work in the private system can be due to the fact that many private institutions implemented the online classes in less than two weeks, to not lose the monthly payment of the students.

4.3 Educational Segment

The third question is about the segment where the responder actuates, they could choose more than one option. From the responders, 98 teach in elementary and middle education, 108 teach in the high school, 23 in undergraduate courses, and 3 in graduate courses.

The number of students enrolled in elementary and middle education is considerably bigger than the students in elementary and middle education, but many students of the first educational years are too young to change the educational system so suddenly and this is a challenge where some schools are working.

4.4 Online Educational Experience

The fourth question is if the responder has experience with online education or not. Most of the responders never taught online classes before, 147, while only 21 has previous experience with online classes.

With this question is possible to understand the number of responders with experience with online classes, and the following questions evaluate how challenging was to these educators to change the educational system.

4.5 Training Provided

The fifth question is if some training was provided to the educators to the online classes. From the responses, 94 of them did not have training provided by the educational institution, 64 had training provided by the institution during the pandemic and only 10 had previous training provided by the institution because they already work in the online classes offered by the institution.

Comparing the responses of this question with the previous question, only 10 respondents were trained by the educational institution, and 11 was used with online classes because they did this previously. Most of the responders had to learn how to teach online alone, with a big waste of time and effort while they were presenting the classes.

4.6 The Online Environment

The sixth question was if the tools used to online classes are part of a system provided by the institutions or if they are multiple programs, for educational use or not, that was adapted to the online classes. From the responses, 116 did not have a system provided by the institution, while 52 was using a system provided by the institution.

4.7 Attendance of Students in Private Institutions

The seventh question was just for educators that are providing online classes to private institutions, asking the percentage of students that attended the online classes. From the responses, 21 (22.3%) were between 80% to 100%, 26 (27.7%) were between 80% to 60%, 17 (18.1%) were between 60 to 40%, 17 (18.1%) were between 40% to 20% and 13 (13.8%) less than 20%.

With these responses, 30 (31.9%) of these online classes had less than 40% of the attendance of students. The number of students attending online classes is considerably smaller than the students that should be present in the presential classes, with this result, the number of students that fail just because they do not have the mandatory attendance in classes (that is 75%) is close to 77.7%.

4.8 Attendance of Students in Public Institutions

The eighth question was just for educators that are providing online classes to public institutions, asking the percentage of students that attended the online classes. From these responses, only 4 (3.3%) were between 80% to 100%, 7 (5.8%) were between 80% to 60%, 25 (20.8%) were between 60% to 40%, 35 (29.2%) were between 40% to 20% and 49 (40.8%) less than 20%.

With these responses, 84 (70%) of these online classes had less than 40% attendance of students. As in the previous section, the number of students attending online classes is considerably smaller than the students that should be present in the classes, but with this result, the number of students that fail just because they do not have the mandatory attendance in classes (that is 75%) is close to 96.7%.

Comparing the results of attendance of public and private institutions is possible to see that both results are bad, but the public system has a significant number of students that do not attend online classes.

4.9 Main Issues Faced by Educators

The ninth question is an open question where the respondents should explain the main difficulties in online classes. All the educators responded to this question with at least one short comment and many of them explained with more details one or more issues.

The main problems addressed by responders are:

- Internet access: 66 comments, mostly about students in public institutions or rural areas, and some comments are also about access to the teachers.
- Interaction and participation: 29 comments, educators do not know how to interact and evaluate the participation of students.
- Increase of work: 25 comments, some educators report that they have to work much more, some of them prepare and edit videos for classes.
- Platform: 20 comments, educators addressed issues with the platform, as instability and other issues that make this difficult to use.

4.10 Comments Made by Educators

The tenth question is an open non-mandatory question where the respondents can leave a comment about the online meetings with students. A significant number of educators (100 or 59.5%) responded to this question. The comments are about distinct aspects of the online meetings but some subjects are more frequent:

- Bad participation: 21 comments, some educators pointed out that the students were not interacting or even participating in the meetings.
- Bad access: 15 comments, some students do not have internet access, or very limited access, which prevents them to participate in the meetings.
- Good interaction: 10 comments, some educators, mostly from private institutions, reported good interaction with the students at the meetings.
- Bad solution: 10 comments, some educators reported that these meetings are bad at all and do not provide conditions for students to learn.
- Professionally enriching: 9 comments, some educators reported that these online classes were challenging for them in a good way, because made them rethink teaching and learn how to teach in this new environment.
- Reasonable: 8 comments, some educators reported that for this pandemic situation this solution works.

5 Conclusions

The 2020 pandemic of COVID-19 destabilized all countries around the world. All people had to adapt their lives to follow the instructions of WHO, so the economy and education had to seek creative solutions to continue developing their essential roles. Brazil was not different from the other countries, but some Brazilian characteristics must be taken into account to highlight the situation by students and teachers. Online education is a complex endeavor and both academics and students may lack the training needed for quality online learning.

Usually, developing online courses involves a team of experts including professors, instructional designers, programmers, and illustrators and require a large knowledge about the functionalities and tools available in the platform from whom is using it. Furthermore, all users must have internet connecting services to access all the information needed for learning, which is not the case for all Brazilian students due to the low financial situation in which they live.

It is important to set realistic understandings that in this quick transition, academics who have never taught online will be offering courses that have not been devised in this way and it may decrease the quality of learning due to lack of structure. Another point to be emphasized is that the health and safety of students and staff should be the top priority. Nobody can have excellent learning if your mental health is compromised with a pandemic situation and financial problems. Authorities should take the responsibility of ensuring food and pay careful attention to student experiences to make the learning more rich and effective.

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Public-Private Partnership and Entrepreneurship Education

Interaction Experience "University-Industrial Enterprise" for Improving Preparation of Engineering Personnel

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Abstract. The article describes the experience of the department in organizing practical training at the base enterprise. The functions of the base enterprise and its role in the training of future specialists are determined. Training methods that activate the cognitive activity of students during practice are considered. The results of the questionnaire after internship showed that students are satisfied with the chosen profession, the level of competency formation has increased.

Keywords: Dual training · Active methods · Strategic partnership · Industrial enterprises · Engineering education · Strategic partnership · Industrial enterprises · Manufacturing practice

1 Context

In a developing knowledge economy, the task of establishing and developing partnerships between universities with industry and the labor market is of particular importance. It involves the creation of a network of organizations interested in mutually beneficial cooperation in the field of training highly qualified personnel, strengthening the material and technical support of the educational process, conducting joint scientific and applied research, modernizing production and manufactured products, etc. For this activity to be as successful as possible, it is necessary to understand how to build a university-industrial enterprise relationship on the basis of mutual interest and usefulness.

A strategic partnership between universities and manufacturing enterprises is a requirement of the time. The main incentive for the formation of long-term partnerships is mutual interest in improving the quality of training.

The problem of the quality of training of future engineers is an important task. The state of the economy and the innovativeness of its development depend on this.

The course adopted today to modernize professional Russian education, aimed at improving the quality of training of specialists at various levels, is impossible without the formation of a single educational and production space and significant changes in relations between enterprises and educational organizations, without cooperation in this area. Experience shows that cooperation is one of the important conditions for ensuring quality training. This idea was also confirmed at international meetings, for example, the G8 Summit in St. Petersburg. The governments of large states declared the need for

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their participation in the field of education and pledged to “take into account the opinion of the business community, higher educational institutions and workers’ organizations” [1].

Long-term strategic partnership “university-production enterprises” may imply various models of interaction. This includes targeted training, and retraining of specialists in relevant professions, and the implementation of technical, research and production tasks with the involvement of leading teachers and students, and the joint development of standards and programs in the field of vocational education and retraining of personnel that satisfy both current demands of the economy and promising directions of development.

A survey of employers, representatives of leading chemical enterprises of the Republic of Tatarstan revealed the following shortcomings (%) in the training of young specialists:

1. theoretical training - 21%,
2. practical training - 56%,
3. computer skills - 6%,
4. knowledge of foreign languages - 21%,
5. business knowledge - 6%,
6. management skills - 15%,
7. ability to work in a team - 21%,
8. interpersonal skills - 10%,
9. insufficient work experience - 40%.

And if you can still agree with the last factor, then the above discrepancies should be eliminated in the conditions of the educational process.

As an analysis of the activities of various companies in the real sector of the economy shows, the period of adaptation of graduates is a rather lengthy and financially costly process. During this period, directly at enterprises and organizations, they undergo training in the necessary professional skills, which is carried out in the form of passing all kinds of internships and certifications. All this allows yesterday’s students to acquire the minimum necessary production experience. No less important are the elements of corporate education - this is, above all, the assimilation of the philosophy and production culture of the enterprise. All this requires not only considerable time, but also serious financial resources.

Preparation of students for innovative engineering activities should be organized on the basis of their inclusion in this activity, there should be a large amount of practical training aimed at mastering this activity. This can be realized by using the potential of industrial enterprises. Potential employers can participate in the organization of training of future specialists through the following activities:

1. provide places for student practice - 100%;
2. attend the defense of theses - 50%;
3. hire graduates - 43%;
4. to conduct advanced training of graduates - 42%;
5. order consulting services - 36;
6. pay for the training necessary for the company specialists - 29%;

7. to take part in financing innovative developments for own production - 21%;
8. take part in the implementation and development of grants together with universities - 18%;
9. participate in the activities of the Board of Trustees - 15%;
10. provide the material and technical base - 13%;
11. take part in equipping laboratories - 11%;
12. provide sponsorship for research in their own industry - 9%.

Networking of professional educational organizations and enterprises in order to implement training is a promising educational practice that most successfully brings together the possibilities of professional education with the demands of modern production. The implementation of the network interaction of professional educational organizations and enterprises has a number of advantages compared to the traditional system of specialist training:

1) the volume of training of future specialists corresponds to the real needs of the existing production;
2) compliance of the content of the educational process with the real level of development of production, taking into account its prospects;
3) conducting examinations of training programs by representatives of the enterprise;
4) the use in the learning process of modern equipment in real production;
5) attracting to the educational process mentors from among the best employees of the enterprise, which in turn provides the necessary practical orientation of the education received by students;
6) the involvement of students in the collective of the enterprise, their adaptation to the norms and rules of behavior, the formation of a value attitude to production activities.

2 Purpose or Goal

Networking of professional educational organizations and enterprises in order to implement training is a promising educational practice that most successfully brings together the possibilities of professional education with the demands of modern production. The implementation of the network interaction of professional educational organizations and enterprises has a number of advantages compared to the traditional system of specialist training:

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6) the involvement of students in the collective of the enterprise, their adaptation to the norms and rules of behavior, the formation of a value attitude to production activities.

A strategic partnership between universities and manufacturing enterprises is a requirement of the time. The main incentive for the formation of long-term partnerships is mutual interest in improving the quality of training.

The Kazan National Research Technological University (FSBEI HE "KNRTU") implements the program "Strategic Partnership". The main objectives of the program are the following provisions. forecasting labor market needs and ensuring early employment of university graduates. Joint development of content, information and methodological and material and technical support of basic and additional educational programs. Joint implementation and resource support of educational programs, technological and undergraduate student practices. Development of professional requirements for specialists. Evaluation of the quality of educational programs and the quality of training of graduates. Support for the activities of expert councils in the scientific and educational areas of KNITU. Attracting students to real design and research activities. The introduction of the educational technology "training through research projects" in the preparation of practice-oriented specialists. Conducting joint innovative development, implementation and production. Organization of advanced training and internships for university teachers and staff on the basis of partner enterprises. Joint training of the highest scientific qualifications. Development of the infrastructure of strategic partnership, the creation of joint educational and research centers, laboratories, basic departments, and collective use centers. Development and testing of effective mechanisms of interaction between the university and partner enterprises. It should be noted that in each case, the strategic partnership agreement should be formed on the basis of bilateral interests, forming a comprehensive program of interaction between the university – production enterprise dipole, which can change and adjust as external conditions change.

As a result of the interaction of two systems - educational and production - the gap between theory and practice is bridged: the student receives knowledge in the educational organization, and skills and professional competencies in real production conditions in the employing organization. Such training creates a high motivation of students to master competencies, since the quality of their training is directly related to the performance of official duties in the future, after graduation.

At the Kazan National Research Technological University, basic departments have been created and are successfully functioning. It is created for cooperation with a specific employer, and the interaction framework in each case is negotiated and formulated individually on a contractual basis [5]. Basic departments are designed to solve the following problems:

– Development of educational practice-oriented programs together with universities;
– conducting all types of practices using the material base and personnel potential of the employing organization;
– management of course and diploma design, research work of students; - internship for teachers of a partner university;

– Attraction of specialists of enterprises to teaching activities; - work in state examination and certification commissions.

The existing experience has allowed us to identify a number of organizational conditions that determine the effectiveness of their activities.

1. Definition of partner enterprises. Collaboration enterprises must be leaders in their industry. This is a prerequisite that will ensure the modernization of the educational process through the use of best practices from leading domestic and foreign companies. These are necessary requirements, since the main value of basic departments for a university is the possibility of improving the educational process by incorporating the best practices of leading domestic and foreign companies. Only in this case, higher education will better meet the current needs of the economy and society. It is the leading enterprises, as a rule, that are the permanent and largest customers of the staff. They have the necessary material, intellectual and organizational-technical base for the creation and successful functioning of basic departments. In addition, the direction of their development is determined not by the current market conditions, but by long-term plans based on a well-thought-out long-term strategy. Enterprises of this level impose increased requirements on their employees and that is why they may be interested in creating basic departments: thanks to their work, they will be able to receive graduates with the necessary set and level of competencies. Therefore, they consciously go to the significant initial costs required for the creation of basic departments, which can reach several tens of millions of rubles, quite reasonably expecting that the effect obtained after a few years from reducing the costs of adapting university graduates will override the investments made [6].

   Department "Technology of inorganic substances and materials" KNITU collaborates with LLC "Research and Design Institute" Technopolis ". The Institute conducts research and development in the field of natural and technical sciences. It carries out activities in the field of engineering research, chemical research, engineering design, construction project management, construction control and field supervision, technical advice in these areas. The goal of creating a basic department in a design institute is the integration of production, science and higher education.
2. Organizational and methodological support for the preparation of bachelors, masters, graduate students. Creating the conditions for conducting training in the studied disciplines, training programs in practices, laboratory practicums, research. Development of targeted training programs for specialists for the enterprise, as well as additional professional training programs for industry specialists, for example, under the program "Advanced Technologies for the Production of Silicate Brick".
3. Equipping the scientific and educational laboratories of the department to carry out scientific research at the expense of the enterprise. The department for use in the educational process received analytical scales Shimadzu ATX224, a dual-beam spectrophotometer UV-1900 (Shimadzu), a gas chromatograph Nexis GC-2030 (Shimadzu) and other equipment.
4. Creating a continuous system of production practices. As already noted, the basic department allows you to concentrate the practice-oriented part of student training

directly at the enterprise, for which bachelors and masters are being prepared. This makes it possible to organize students' internships directly at the place of their future work. In the case of the basic department, both the student and the employer can already determine the future place of work of the graduate during the training period. In this case, the leading specialists of the corresponding unit perform the functions of peculiar mentors, which helps to narrow the gap between the theoretical knowledge of the future young specialist obtained in the educational process and his further practical activity after completing studies at the university. In fact, this removes the need for professional adaptation.

5. Attracting specialists of the enterprise to teaching. The head of the basic department is a teacher of the department of KNITU, which ensures the unity of approaches to the organization of the educational process.

Starting from the first year, study tours with workshops and departments of insight are held with students, the latest production equipment, used technologies and manufactured products are demonstrated.

Let us dwell on the issue of practical training. The purpose of production practice in the aspect of the problem under consideration is to create conditions for the trainees to master professional activities. Consequently, the process of passing the practice should be built in such a way that the technology, forms, teaching methods contributed to the achievement of the goal in the process of activity (passing the practice) of the trainees; the content varied according to the degree of increasing complexity of the actions performed and the degree of independence of the trainee in their implementation.

Industrial practice serves to consolidate the theoretical and practical knowledge of students, to collect material related to production technology, the principle of operation and design of the main equipment, labor protection system, technical and economic indicators, quality management methods, issues of ensuring industrial, industrial and environmental safety.

The practice program provides not only consolidation of theoretical knowledge acquired by students during training, but also enables the enterprise- employer to evaluate the business and professional qualities of student students. To assess the quality of training of future specialists, it is mandatory to obtain feedback and characteristics on student interns.

3 Approach

As a result of the interaction of two systems - educational and production - the gap between theory and practice is bridged: the student receives knowledge in the educational organization, and skills and professional competencies in real production conditions in the employing organization. Such training creates a high motivation of students to master competencies, since the quality of their training is directly related to the performance of official duties in the future, after graduation.

To conduct the study, the experience of foreign countries, Russia in the field of the relationship between higher education and industry was summarized. An analysis of foreign sources based on the work of researchers from the USA, France, Germany, China, Japan, and Mexico shows that the search for a solution to this problem has long occupied scientists and statesmen in many countries. It is dealt with, both separately, within one country, and within the framework of international programs in which 15–20 countries participate. Forms of the relationship between universities and enterprises are mostly typical and applicable simultaneously in several countries.

Foreign researchers pay great attention to the problem of developing the relationship between universities and enterprises. It was revealed and classified more than 10 ways of practical implementation of the relationship between universities and enterprises, which indicates the relevance of this issue abroad.

If you arrange the presented points of view in decreasing order of the number of researchers who highlight a particular negative phenomenon, you can get an idea of the most and least common points of view.

1) the problem of employment of graduates.
2) the problem of the mismatch of supply and demand in the labor market;
3) inconsistency of knowledge and skills of graduates with the requirements of employers;
4) the role of the university in the economy to meet the needs of industry to achieve economic growth.

The resulting picture coincides with the situation in Russia, when the main tangible problems are the problem of employment of graduates, and the problem of incompatibility of knowledge and skills of graduates with the requirements of employers.

Member of the European Commission Edith Cresson in the article “Education and Development” notes that in the field of higher education the main task is to give young people the most complete picture of the work of the enterprise. According to Cresson, the problems of youth employment often arise due to the too narrow specialization of future technicians, managers, and engineers [7].

The activities of a modern enterprise, its development strategy are influenced by factors of internal and external environment. Intellectual capital is a key internal factor in the activities of the 21st century company. The most important component of intellectual capital is the workers of intellectual labor. An enterprise will be able to develop successfully only if the human capital that it possesses will correspond in its characteristics to the current and future needs of the enterprise, determined by the development trends of the corresponding industry. Human capital, as a set of competencies of employees used to meet the needs of society, is able to ensure the competitiveness of the organization in a market environment. The main role in the formation and development of this capital belongs to educational institutions of higher education: universities are called upon to solve the problem of ensuring the quality of training of highly qualified personnel in accordance with the requirements of employers.

The need for highly skilled and initiative workers is aggravated in the new conditions, leading to the natural integration of the university and the main employers, consumers of their services. Integration allows employers to effectively participate in the formation and equipping of a training program, lay down their technological “platforms” in the conditions of specialization, actively get acquainted with future graduates, involving them for practical training and participating in projects on their problems.

A personality-oriented approach allows you to: identify trends and ways to implement the network interaction of a professional educational organization and enterprise; identify and describe the main effects and results of network interaction for students: subjectivity, responsibility, independence, intellectual and production potential; to form the desire of students, teachers and tutors to actively participate in the process of dual training and interest in its high result; to take into account when developing and implementing network interaction the personal characteristics and interests of all students; pick up a mentor for each student, taking into account the personal characteristics of both.

The technological approach allows you to: describe the forms of interaction of all subjects of dual learning in the network interaction of a professional educational organization and enterprise; determine the goal of implementing network interaction and the necessary steps to achieve it; to identify the totality and sequence of actions of all subjects of network interaction necessary for its effective functioning; to determine the criteria and indicators of the quality of students' training in the implementation of dual training and to form diagnostic tools for their identification; pre-design the process of interaction between students with mentors and the administration of the enterprise.

Teachers need to know the technical equipment of enterprises. We ourselves will participate in the development and implementation of technical innovations that graduates will use after employment [8]. An important component of cooperation is the participation of teachers of KNRTU in the annual conference of young specialists of the association. At the same time, young specialists often report on the results of solving production problems obtained in the framework of bachelor's and master's theses. Thus, there is practically no distinction between the production and educational-professional tasks being solved, between the teachers of KNRTU and the leading specialists of the design institute conducting joint research. Joint participation in grant competitions, a production association co-financed work for 9 million rubles. Further development of cooperation was obtained in the framework of the preparation and implementation of the project Gypsum composite materials with increased water resistance. Mineral modifiers for autoclaved hardening materials (silicate brick and foam glass).

At the beginning of the practice, students were offered a technological game, which is held for two days. In general, 6 h are allocated for the game. Before the start of the game, personnel were selected for a conditional enterprise, all students were appointed to positions. The period of the game corresponds to the year of production and economic activity of the enterprise, tasks are given to the conditional management apparatus, initial data imitating production. A package of specific situations is prepared for each unit, according to which managers make decisions. According to the proposed situations, students must make the right technological decisions with the calculation of the expected effectiveness.

The use of coach technologies in the process of production practice at the enterprise allows you to adapt the educational process to the individual characteristics of the student and make it more effective, to intensify the assimilation by students of the skills necessary for future production activities. During the practical training, the mentors suggested that the students present a non-staff course of the production situation, predict its possible consequences and find solutions. After that, students were asked to critically evaluate their results, identify errors, find more effective and less energy-intensive ways to perform production operations. Here are examples of the implementation of coach technologies: the method of "competition" or "professional competition" was implemented in the process of production practice, in which students produced goods by order of the structural units of the enterprise; The solution of technical cases during the practical training was applied with the aim of forming professional competencies among students. The "Action learning" method was also used. This method is based on the teaching formula of M. Markuardt, according to which the existing knowledge can be expanded and deepened through the gained experience of actions, through its discussion and analysis.

Consider the situation when it is possible to use this method in the production process. When undergoing practical training, the student enters the production environment where a team of employees solves the production problem, for example, they carry out joint work on a project to automate the process. The process of working on a project is divided into several stages. Each employee, when performing a certain stage, will fulfill the individual task assigned to him. After each stage of the project is completed, an analysis and discussion of the results are carried out, setting goals for the next stage and planning steps to achieve them, as well as the distribution of tasks. Another task is to develop a modernized technology for the production of silicate brick. This problem is promising, since this product, losing in many consumer properties, in comparison with ceramic brick, has almost half the cost, lower price, significantly lower (more than twice) the initial investment in production. The range of silicate bricks of individual enterprises reaches 30 types. It is possible to produce ordinary silicate brick of good quality, which actually has no competitors among wall materials in its price category. Along with the use of various dyes, giving the brick a wide range of colors and shades, additives are also used - modifiers that give the brick increased strength, moisture and frost resistance. Some successes were achieved by students, but they failed to fully adapt the technology to the specifics of the raw materials and the equipment features of the enterprise. The obtained brick samples did not fully meet the requirements, technological problems arose that showed the need for additional studies on the use of fly ash as a raw material.

This refinement can only be carried out with the participation of the scientific potential of the university, specialists of an industrial enterprise.

Pouring into this production process, the trainee is given the opportunity to solve real production problems by working together with a mentor. Thus, apply his knowledge in practice, expanding it and gaining new knowledge and skills through discussion, analysis and understanding of his own experience in solving production problems.

4 Results

Students who, during practice, declared themselves as a potential researcher and demonstrated their readiness to work in the enterprise, the company draws up part-time staff for the afternoon, and they send them to target training on a contract basis as their employee. The contract that the student signs with the company when sent for targeted training sets out the period that he must work after receiving the appropriate document on the development of the annual program of targeted training and penalties, the application of which has never been necessary.

To conduct classes with students, leading specialists and managers of the enterprise are involved, which allows you to organize the teaching of special disciplines with practical and laboratory work directly in the departments of the existing enterprise. The established close contacts between teachers and specialists of the production association made it possible for students to complete all types of internships at the enterprise. Starting from the first year, study tours are conducted with students in the shops and departments of the enterprise, the latest production equipment, used technologies and manufactured products are demonstrated. A familiarization practice, as a rule, is associated with the study of the work of a particular workshop or department, production practice is based on the work of trainees at specific workplaces.

Industrial practice performs the most important functions in the system of professional training of students:

- teaching - updating, deepening and expanding theoretical knowledge, their application in solving specific situational problems;
- developing - the development of cognitive, creative activity of future specialists, the development of thinking, communicative and psychological abilities;
- educative - the formation of a socially active personality of a future specialist, sustained interest, love for the profession;
- diagnostic - checking the level of professional orientation of future specialists, the degree of professional suitability and preparedness for professional activity.

During internship in production, the student keeps a diary in which he notes the types of work performed, fixes his observations, makes generalizations and conclusions. At the end of the field trip prepares a report. Industrial practice is a great contribution to the training of future specialists and is very effective in the process of the upcoming adaptation of specialists at the enterprise.

After completing the practical training, a questionnaire was used to interview students. The survey was attended by 87 students. They listed the competencies that were formed during the internship: research planning; foresight thinking; forecasting, systemic thinking; leadership and leadership; teamwork skills; the ability to analyze problem situations and choose appropriate methods for finding solutions based on established limitations and system resources; the ability to find the optimal solution to a problem situation within the framework of professional tasks, based on constructed models of contradictions; the ability to conduct research, critical analysis, generalization and systematization of information; the ability to set goals and choose the best ways and methods to achieve them; possession of a systematic view of the subject and object of study; the ability to use interdisciplinary methods and approaches in scientific research; ability to solve actual practical problems in their professional field; the ability to improve and develop their intellectual and cultural level; the ability to generate new ideas (creativity), adapt to new situations, overestimate accumulated experience, analyze their capabilities. Students also praised the conditions for organizing the learning process at the base department, and their attitude to themselves as future colleagues.

Respondents had the opportunity to choose several answers to one question. The questions concerned the place and time of the internship, assessing its usefulness in terms of getting acquainted with various areas of the enterprise, contacts with managers from the enterprise and the university, as well as with the future work of graduates. The questionnaire on the level of organization of practice was of a general evaluative nature. Students mostly gave positive answers to it: "Fully or basically satisfied with the level of organization of practice on the part of the university" - 94.25%, "Fully or basically satisfied with the level of organization of practice on the part of the enterprise" - 98.29%, "Unhappy with that how the practice was organized and conducted "- 3, 46%. About 90% of students rated their work experience as useful and effective, and 5% spoke negatively about it. Students noted that the practice gave them nothing or almost nothing in terms of their future profession. For most students (from 40% to 80% depending on the direction of training), practice has confirmed the correctness of the choice of profession.

Field trip is a tripartite process of specialist formation. The university, the student and the enterprise where the practice is organized should take part in it.

When evaluating the head of practice from the enterprise, the results of the survey showed the following: 67.8% of students had the opportunity to use the documentation; 49.4% received comprehensive answers to questions of interest; 38.9% - the head of practice told about the organization of work at the enterprise, organized a tour; 25.28% - helped determine the actual problems on the installation. However, 8% of students, the head of practice, could not take the time.

Answering the question: "What kind of help would you like to receive from the head of the practice?", The students suggested the following: organize tours of the installation (object of practice) (45.97%), help to understand the technological scheme (51.72%) and in the drawings equipment (42.52%). When assessing the role of the practice leader from the university, students noted that the leader was interested in and controlled the writing of the practice report (34, 48%), organized consultations (25.28%), periodically checked sections of the report (25, 28%). Students in their responses also noted the help that they would like to receive from the head of practice from the university: the organization of training (consulting) classes at the place of practice (14.94%); assistance in finding places of practice for students with health restrictions (9.1%).

The results obtained revealed an interesting pattern. Leaders from the enterprise devoted more time and provided all possible assistance than the leader from the university.

According to the methodology of Professor N.V. Kuzmina calculated the coefficient of satisfaction with the chosen profession: if it is more than one, then they judge how many satisfied there are one unsatisfied. According to our data, the satisfaction rate is 9.2. You can judge the direction of future university graduates to work in their chosen specialty. There is an increase in the number of students with a high level of cognitive level of 16% and activity level of 12% of competency.

Another important research question was the level of employer satisfaction with university graduates. As the survey showed, the vast majority of enterprises of the Chemical Complex of the Republic of Tatarstan (92%) already have graduates from KNRTU over the past five years. At the same time, about three quarters of enterprises are satisfied with the level of training of university graduates, including: completely satisfied with the quality of training of specialists - 19%, rather satisfied - 56%, partially satisfied - 19%, rather or completely not satisfied - 0% (6% of respondents answered this question).

The study helped to answer the question of what enterprises could offer university graduates who want to find a job for them. These proposals are as follows: interesting work in the specialty (98%), decent salary (56%), a package of social support (75%), work with modern technologies and equipment (69%), training and professional development (83%), career growth prospects (85%).

This allows us to conclude that enterprises in general are ready to form profitable job offers for university graduates, provide interesting work, offer growth prospects and professional development opportunities. At the same time, only a little more than half of enterprises (66%) are ready to offer graduates decent wages.

5 Conclusions

Based on the existing Russian experience of dual training, it can be stated that dual training in the framework of modern Russian realities has the following main advantages and disadvantages. The advantages include guaranteed employment of a graduate, gaining production experience, as a rule, required by employers from applicants for vacancies in the company. From the point of view of the employer, the plus of such training is getting a ready-made highly specialized specialist in accordance with the requirements of this company, already adapted and not requiring the cost of retraining it at a new workplace.

The main disadvantages of this model of training include insufficient funding, as well as the manifestation of non-interest on the part of employers. As for students, it is not always possible for a person to clearly imagine what he wants from his future profession, whether it will be able to fully realize his needs, and the need to “work out the funds invested in him by the company” can subsequently become burdensome for a person. In addition, when using remote Internet technologies, the student’s independent study of complex engineering disciplines after a working day at the enterprise will not always allow the student to achieve a high level of theoretical knowledge in the studied disciplines.

At the same time, the dual form of training, as you know, is the product of close interaction between educational institutions and employers to train the future employee. This leads to a reduction in the imbalance between the needs of the labor market and the training system of educational institutions of vocational education. The use of the dual form of training is dictated by the understanding that modern production requires a highly skilled worker with a creative approach to production activities. And to prepare such an employee is possible only with the effective cooperation of all social partners, especially the educational institution and the employer. Partner enterprises are ready to form profitable job offers for university graduates, provide interesting work, growth prospects and professional development opportunities. The base enterprise is actively involved in the development of educational and methodological documentation, in equipping the material and technical base of the educational institution. A mandatory element of the educational process conducted at the basic departments is the organization of a continuous system of practices that allows students to carry out a consistent change of jobs and engineering positions in the departments of the enterprise, which is the most important condition for the formation of the required set of professional competencies. This will not only increase the efficiency of the basic departments, but also provide an opportunity to create around them a training, scientific-production and socio-cultural zone of a continuous innovation cycle of enterprises.

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Team Building Technologies in Engineering Education

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Abstract. The paper discussed the effective team-building technologies in engineering education. The relevance of the research is due to academic and industry based research the emphasized the need for competitive engineers who possess professional competencies and personal qualities as well as engineering graduates who need to work on solving complex problems in teams composed of professionals from many disciplines. The paper describes supported by examples how teamwork can be integrated into the curriculum in conjunction with engineering projects and topics. The research emphasize that students need to understand principles and attributes of effective teamwork, practice teamwork, receive feedback on teamwork, and adopt practices of self-monitoring and self-regulation in their teams. The study offers a methodological training system that includes active teaching methods and a more pragmatic approach in teaching students the skills necessary to function as effective and productive team members. Teamwork skills are increasingly being sought when hiring engineering graduates and employers assume they raise the status of an organization in the market and increase its profit by improving the quality of solving interdisciplinary tasks with minimal time costs and maximum productivity. It also motivates employees and facilitates bonding within the company, opportunity to work together in close proximity leads to strong relationships.

Keywords: Team building technologies · Collaborative learning · Engineering university

1 Introduction

1.1 The Urgency of the Research

During last decade academic and industry based research has emphasized the need for competitive engineers who possess both professional competencies and personal qualities as well as engineering graduates who need to work on solving complex problems in teams composed of professionals from many disciplines and exhibit high level of communication skills. Ability to function effectively within a team is one of the important graduate attributes for engineers [1]. At the moment, various projects and design technologies are being actively introduced in production. Therefore, professionals able to work efficiently as part of different creative teams are becoming more popular. Team members need to coordinate steps and actions in joint activities, maintain a high pace of work, understand and solve their individual tasks to achieve a

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common goal and potential. The solution of the stated issues on the training of such personnel is linked with the active introduction of team building technologies, flexible methods and teamwork skills into the process of training students.

Nowadays ability to think creatively and work in a team becomes one of the most important skills. We need to find a new methodological training system that includes active teaching methods and a more pragmatic approach in teaching students, the skills necessary to function as effective and productive team members. Teamwork skills are increasingly being sought when hiring engineering graduates and as employers assume they raise the status of an organization in the market and increase its profit by improving the quality of solving interdisciplinary tasks with minimal time costs and maximum productivity. Researchers also talk about their motivational capacity in engineering education [15, 7], team building facilitates bonding within the company and gives an opportunity to work together in close proximity that leads to strong relationships [2, 6].

Initially, an academic group is not a team, as it is organized spontaneously from people with different levels of knowledge, life experience and ambiguous attitude to team work. But in the learning process, students interact with each other, acquire new knowledge and skills, solve the tasks assigned to them, gain teamwork skills, and gradually, a student group becomes a team. It is possible to organize students' team work if team technologies are not applied fragmentarily in a separate discipline, but during the entire educational program, then students would gain the experience of team interaction. "Weaker" students can get more benefits of working in a team when they work with "stronger" students.

As a rule, a student group consists of a constant number of people, and it is impossible to find candidates for certain team roles, taking into account the level of training, personal qualities and psychological characteristics. Therefore, student teams are aimed at reducing and overcoming interpersonal conflicts and the level of hostility, understanding each other, teambuilding contributes to the positive emotional interaction of its members, encourages creativity, self-management and self-development when performing joint tasks. All above mentioned purposes of teambuilding define the relevance of our research.

Compared with an ordinary group of people, a team has a number of advantages:

- a team consists of like-minded people which is better and more effective than working individually;
- the possibility of team members displaying their talents and skills is higher;
- flexibility and mobility of team members, their ability to quickly adapt to new working conditions;
- versatility of team members, which makes it possible to solve a wide range of work tasks and problems;
- cohesion within the team, creativity and collaboration.

During the university period, a team which was spontaneously formed from students with different backgrounds from the first-year to senior year goes through all the stages of team development including team formation, its functioning and breakdown after graduation. The authors of this study conducted observation for three years. Two groups of bachelor students learned English on their 3rd and 4th year.

1.2 Literature Review

Team building and teamwork skills have been studied by different sciences such as management, economics, psychology, sociology, pedagogy, and others. Most researchers consider a good team as and innovative resource for company development with a shared leadership roles and specific team purpose, and effective team building is in active problem-solving meetings with open-ended discussions and performing collective work products when real work is done together [8, 12]. Smith [11] states that effective teams have positive interdependence, individual and group accountability, they promotive interaction, teamwork skills, and group processing.

Cooperative or Team-based Learning was used in Germany, the Netherlands, the UK, Australia, Israel, and Japan. But basically, team-based learning technology was developed by three groups of American educators from Johns Hopkins University (R. Slavin), University of Minnesota (Rogers Johnson and David Johnson), and a group from California (J. Aronson). The ideas of teaching in cooperation throughout this time have been developed by the efforts of many educators in many countries of the world. Johnson and Johnson [5] point that to be cooperative and reach the full potential of the group five essential elements need to be carefully structured into the situation: positive interdependence, individual and group accountability, promotive interaction, appropriate use of social skills, and group processing [4, 12].

Scientific literature analysis on team building technologies and team development shows in most cases the attention of scientists is paid to successful business team organization and the interaction of employees in the business community [3]. Therefore, it is necessary to adapt well-known business technologies to the educational process. Teamwork fits into the paradigm of "student-centered" training, which is quite relevant today, as opposed to the adaptive-disciplinary model, where the teacher has a leading role [14]. Interaction involves formal equality in discussing problems between the teacher and students.

In our article, we will analyze the most successful techniques and examples of team training, in particular, the features of training in the cooperation of foreign language students in a non-linguistic university.

2 Research Methodology and Materials

Team-building is based on student-centered approach, which is widely used nowadays compared to the teacher-centered model, where the teacher has a leading role. Interaction means formal equality in problem discussion between the teacher and students (it is clear that the teacher should emphasize this equality, while managing discussion). Second of all, teamwork lays on project-based learning, which is used in various ways in different universities around the world.

Research participants are Master students (total number 100 people) majoring in Technosphere Security. We observed them in Bachelor Studies and found that 50% of students in the third year had a low level of readiness for teamwork and experienced the fear of teamwork due to difficulties in establishing contacts with their classmates and lack of flexibility in communication. 29% of respondents have an average level of readiness for team work, this indicates the possibility of students conducting team activities only under the supervision of a teacher, who designates rules for each student and controls them. Such a team can work effectively only under certain circumstances. 21% of respondents showed a high level of team work. These students know how to interact and can easily use teamwork skills in their studies. Active training methods are used to develop team-building skills.

We use a set of systemic, competency-based, learner-centered, interactive and axiological approaches to ensure effective collaboration and teamwork skills which are based on creativity, dialogue, trust and personal responsibility in achieving a common goal. Teachers use blended learning (flipped classroom) and different activities such as lectures, results analysis, discussion, and practical work. For example, 20 min for lecture on the topic “The History of Chemical Science”, followed by a questionnaire on a well-known scientist-chemist, where students try to guess different scientists using questions. The key condition is to choose a learning material with an appropriate level of difficulty, clear explanation of tasks (no more than 10 min), results analysis and lecture discussion (10–15 min), finished with lecture. Such a lecture can be followed with practical work on a lecture subject for 15 min. The big problem is student’s ability to do tasks independently. Moreover, most students face big challenges with search engines when they need to find answers to the questions as they don’t know how to form questions correctly. At the beginning of the training, we have a workshop on teamwork technologies. Our aim is to give information on team building technologies: planning, estimating, tracking progress, managing changes and risks, communicating complex ideas clearly, and participating effectively as team members. Workshop goal is to inform students on the stages of team building: acquaintance, general vision, positioning, planning, and action.

It is necessary to make changes to the educational process in order to enhance student’s motivation to acquire the skills of independent cognitive activity, i.e. to form the ability to think creatively. While studying “Types of Technosphere Safety”, students are organized in groups of four to six people and every group works with educational material divided into fragments that are logical or semantic blocks. To get the full picture students search for missing pieces of information so that this technology involves teamwork. This type of team activity is effective when students work with special texts, reading and discussing professionally oriented vocabulary.

Master’s degree students were ready to work as a team when they had a class called “Managing Learning Processes”. They can independently assign roles and are responsible for assigned task. For example, a group of students chooses the topic “Reducing noise in compressors”. They study causes of noise and develop different ways to reduce noise while compressors operate, and suggest special noise-insulating materials. They propose to replace a compressor running on rolling bearings with magnetic bearings and emphasize on a number of advantages such as low noise, since metal-metal friction does not occur; increase in efficiency due to increase in rotor speed. When replaced with magnetic bearings, the noise level is reduced to 40%, which economically efficient. Doing these tasks, students develop the following teamwork skills as empathy, dialogic communication, and productive feedback.

3 Discussion

3.1 Team-Based Technology in Foreign Language Teaching

Team-based teaching, as a component of the Communicative Language Teaching is becoming increasingly popular in teaching foreign languages in higher education. According to the researchers, this technology puts the student at the center of the educational process and organizes its interaction with other students [9, 10]. This technology of teaching a foreign language contributes to the creation and development of an innovative educational environment in a non-linguistic university. A language teaching is organized according to the principle of teamwork. The group of students is divided into teams of 4–5 students. The teacher gives each team the task of developing different topics. Students distribute the roles and contributions that everyone makes; they also plan the volume and progress of its implementation, structure of presentation upon completion of the work.

Teaching English at an engineering university is focused on studying vocabulary and terminology, reading specialized technical literature, and communicating in the field of professional activity. Students need to develop communication skills to be able to communicate in English on professional level. They need to master formal and informal language, participate in group discussions and learn to share their opinion on variety of engineering topics.

Student Team Learning is one of the examples of successful implementation of team-based learning. The main idea of this model is to create conditions for group activities of students. According to researchers, the training method in a team comes down to three basic principles: “rewards” (team rewards), when a team receives one “reward” for all in the form of an assessment of joint activity; individual accountability, where the success of the entire group depends on the successes or failures of each of its members, which encourages all team members to monitor each other's successes; equal opportunities for success, while each student brings points to his group, earning them by improving their own previous results [13]. The main advantage of teamwork is in active participation of students and the emergence of communication opportunities. The effectiveness of this method depends on the implementation of several aspects: training students to work in groups, the constant inclusion of this activity in the educational process, the distribution of roles (timekeeper, press secretary, researcher, scientist), monitoring the joint implementation of tasks. A group discussion of a number of questions on a specific topic (for example, “The History of the Development of Chemical Science”), exchange of opinions, the ability to ask questions and agreement/disagreement, the ability to listen and understand are examples of successful teamwork.

Jigsaw method is another option for organizing educational activities in small groups, when students organize in teams of four to six people and work on learning material, which is divided into fragments – logical or semantic blocks. This technology involves the collective work of students in the search for missing pieces of information to get the full picture. This type of training in collaboration is effective when working with special texts, reading and discussing professionally oriented material. The jigsaw method covers all four types of speech activity, allowing students to process information in a "comfortable" environment. For example, a student is issued a card indicating the name of a well-known chemist, the task of the rest, using questions, is to guess the alleged person. The key condition is the choice of material with the appropriate level of complexity; clear statement of tasks.

Role-play is also an effective method of team-building activity. In role-playing, a group is usually divided into small groups, often couples, various conditions are modeled, situations as close as possible to real ones, and roles are distributed. Role-playing game gives many different opportunities to develop communication and negotiation skills, stimulates creative thinking, and involves problems solving. Studying the topic "Safety Rules in Chemical Laboratories", students model a business game by simulating a laboratory class, distributing roles, offering visual material, studying the necessary vocabulary, and reaching the ultimate goal - instructing correct and incorrect behavior in chemical laboratories.

The Learning Together method involves dividing the group into three to four people, who can be both homogeneous in terms of foreign language proficiency or combining weaker and stronger students. This approach has a number of advantages, including mutual learning, providing the opportunity for joint discussion, separation and comparison of acceptable answers to questions or situations, using the target language, working in pairs of strong and weak students. The Learning Together technology can be successfully applied when studying the topic "Types of Engineering", while the task of each group is to prepare information on the types, achievements, pluses and minuses of engineering activities. There are various options for using this method during classes:

- peer review, when partners exchange projects or written works and analyze each other;
- artificial debates, structured public discussions that allow students to show their point of view and convince a third party of their innocence (when discussing the advantages and disadvantages of engineering);
- dialogues that are aimed at repeating and consolidating authentic phrases and expressions in accordance with the context.

3.2 Cinquain Technique in Team-Building

Cinquain is a five-line poetic form that appeared in the USA at the beginning of the 20th century under the influence of Japanese poetry. In the future, it began to be used for educational purposes as an effective method for the development of figurative speech. Cinquains are useful as a tool for synthesizing complex information, as a slice of the assessment of students' conceptual and vocabulary. First of all, educator's task is to explain to students that cinquains fit knowledge, thoughts, feelings, emotions, and associations in a short from. These five-line stanzas are able to express opinions on any issue, subject, event, or phenomenon. Educator explains the basic rules for writing five-line stanzas providing a few examples. In this genre, verse has both a strict meter and rhyme scheme. Cinquain is usually unrhymed and defined by the number of syllables in each line—the first line has two syllables, the second has four, the third six, the fourth eight, and the fifth two. The text itself is based on the meaningful and syntactic meaning of each line rather than on syllabic dependence. The first line embraces the theme of the cinquain, which contains one word (usually a noun or pronoun), which designates the object or subject that will be discussed. The second line – two words (most often adjectives or participles), give a description of the signs and properties of the object or object selected in the cinquain. The third line is formed by three verbs or participles that describe the characteristic actions of the object. The fourth line is a four-word phrase expressing the personal attitude of the cinquain author to the described subject or object. The fifth line is one word describing the essence of an object or object. Strict observance of the rules for writing cinquain is optional.

Cinquain writing is a form of free creativity, requiring the author to be able to find the most essential elements in material, draw conclusions and formulate them briefly. It is recommended to use cinquain as a final task on the material covered. Work can be organized both individually and in pairs. Such topics as "Environmental Protection", "The Earth", "Enormous, generous", "Live, produce, pollute", "We must protect", "Our planet can be organized using cinquain technique.

3.3 Developing Teamwork Skills Based on Urgent Engineering Topics

A round table "Advances in technology" consists of several steps. First step begins 1–2 weeks before the round table with the problem and the purpose of the discussion formulation. Students receive the task: to collect information from various sources about the problems, dangers, threats and benefits that accompany the rapid development of technology in the modern world. A problem is diagnosed and discussed during the class using a brainstorming session. Students are looking for an answer to the question: Have advances in technology caused problems in society? We received the following answers from students pointing at them main problems caused by technology and engineering as ecology, dependence on computer and phone, obesity, problems with transport. Then students make and deliver presentations on the problem with necessary attributes of presentation such as its content, relevance, illustrations, and logically connection. In order to deliver presentations effectively students are recommended to watch videos that help them to greet properly round table participants, present themselves and their report, express their point of view, support the conversation, fill in pauses, put forward arguments and counterarguments, answer questions and end a presentation. Second step is a round table session itself where students give presentations with research results and discuss them in groups. The participants in the round table sit in a circle, facing each other, so that they can clearly see and hear each other, as well as freely use non-verbal means of communication. It is important to maintain a high level of activity for all students, comply with the regulations, and create a friendly and motivating atmosphere. Students listen to and learn about presented topics, discuss them with others, share their thoughts and ideas about each problem. The effectiveness of the discussion depends on students' preparation, awareness and competence on the proposed problem.

At the final, students filled in a questionnaire about their experience. The survey data indicate that active learning techniques as round tables help students better understand the educational material (65% of respondents were positive); have more opportunities for individual work with an educator (82%); get more opportunities to master independent work skills (74%).

4 Results

Team building skills are developed among engineering university students majoring in "Technosphere Security" and its methodology is based on cognitive, process-reflexive components. We developed and improved specific teamwork skills involving bachelor's degree students while teaching English as foreign language and master's degree students while teaching a class "Managing learning process" based on various educational methods such as (diagnostics, discussion, case methods, group project), techniques (productive feedback, empathic, reflective), tools (cases, professional tasks, diagnostic techniques, projects) and forms (group discussion, practical exercises, project defense). Students were able to self-assess themselves as team members, self-determine their choice of team roles and ways of organizing a team, build interpersonal relationships and solve joint professional tasks. We based on A.A. Kyveryalga methodology to group the indicators while determining team building skills acquisition of engineering university students. The significance of this methodology for our study is that it allows not only to evaluate, but also to control the change in the level of each student, to analyze the dynamics according to certain criteria for each individual respondent and the group of respondents as a whole. At the end of the experiment, 29.31% of students remained at a low level for team work, 31.76% were on average and 38.93% at a high level. As a result of successive stages of training on the example of different classes and years, students could improve their team building skills.

After analyzing students' profiles we obtained the following results: students consider working in groups interesting (83%), productive (67%), nothing changed (50%). The advantages of group work they see in being more productive (33%), working more actively (50%) and talking more (83%) compared to front work. As disadvantages of group work they pointed: none (50%) and hard work (50%). Students got more interested and involved (100%), gained more confidence (83%) and became passionate about engineering and technology (67%). Percentage of students who prefer more team-based activities instead of other activities on regular basis (67%), once a month (17%) and sometimes (17%). Team-based activities motivate (83%), cause interest (83%) and cause fatigue (17%) to students.

We conducted a written survey according to the method of T. Ilnaya, which showed the following results of students' motivation: 85% of the students asked showed an increased level, 10% showed an average level of motivation, 5% showed a reduced level of motivation. Students have a desire to acquire knowledge for self-development, which is an indisputable plus for further education. Based on the survey results we determined that the motives of curiosity and the motives for acquiring professional knowledge are ones. The motivation for obtaining professional skills and competencies is the highest, which indicates the awareness of the taken major.

5 Conclusion

Specifically organized learning process that develops and improves team building skills of the university students allowed us to use a methodology aimed at educational tools and techniques for students to study their personal qualities, team roles and interpersonal relationships in a group. The results of the experiment, which was held at our university with the same groups of students (100 people in total), proved that the work was successful. The data obtained indicate an increase team building skills of students. This study does not cover all aspects of the this problem. Further work may be devoted to the development of an online resource for university teachers that help to organize students team work virtually, which is very important during the coronavirus epidemic.

We can name certain advantages of team-based learning: a greater number of students can simultaneously speak a foreign language, which contributes to the development of a foreign language communicative ability; successful students can help underperforming students, so that a relationship of mutual assistance and mutual responsibility is formed; increased sense of responsibility; the psychological climate improves; students are motivated by the opportunity to present the results of team work to other groups; educational and cognitive motivation increases; anxiety level decreases; equally distributed work in a group, there is an opportunity to share ideas and thoughts.

Work in a team makes students more responsive to the task, because the result of their work depends on the overall result of the group. Weaker students get the opportunity to learn from stronger ones or perform more complex tasks that raises their self-esteem and allows them to believe in themselves. In addition, students develop social skills, their ability to work in a team, and this is important for further professional life. Teacher's function here is observation since it is a student-centered approach students themselves are forced to show activity.

This study does not cover all aspects of the identified problem. Further work may be devoted to the development of an electronic educational resource for university teachers in the diagnosis and organization of student teamwork, which is very important during the coronavirus epidemic.

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The Influence of the Innovative Component on the Training of Specialists in the Field of Chemistry and Polymer Technology

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Abstract. Modern economy is innovative and the main factor in developing competitive production is training of engineering specialists with intellectual and creative capabilities The proposed methodology, based on the combination of two areas of training (economics and chemical engineering), provides training for highly qualified specialists in the field of polymer chemistry. Its effectiveness is confirmed by the high demand of the management of the chemical industry, improving the skills of their employees in these programs. The methodology for constructing the educational program and the organization of the educational process is in close cooperation between the university and industry. These programs are aimed at ensuring that teachers perceive this training as an opportunity to reveal the entrepreneurial spirit for students to be more entrepreneurial in their follow-up activities. Entrepreneurial skills allow graduates to conduct business more rationally and purposefully, focusing on pre-planned results. The presence of these skills significantly increases their value in the labor market.

Keywords: Innovative component engineering education · University · Entrepreneurial skills

1 Preparation of Master's Degree Students of Innovative Entrepreneurship in Field of Technology Processing and Production Polymers

Kazan National Research Technological University is famous for its fundamental chemical education. Today, masters receive a single basic education and a block of disciplines of a variable format, depending on the master's program. At KNRTU, classical fundamental Masters are trained in the area "Chemical Technology". According to the program "Chemistry and Physics of High-Molecular Compounds", the list of disciplines of the variable block includes Physical chemistry, Chemical physics of aging and stabilization of polymers, Catalysis in the processes of polymerization and polycondensation, as well as in the processes of copolymerization and copolycondensation, Polymer Rheology, Multicomponent polymer systems, Promising methods for producing and processing polymers and composites, Catalysis and

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mechanisms of chemical reactions, Nanotechnology in the physics and chemistry of polymers, Inorganic polymers, Radical and ionic polymerization.

However, today the modern economy and all transformative activities are innovative. In this regard, the main factor in updating production is a specialist with his intellectual and creative capabilities [1]. The development of the education system is rationally to carry out in three areas. And one of them is the organization of training for specialists with an innovative component, including managers for the management of technological innovations [2, 3]. Therefore, in 2012, at the Institute of Polymer, together with the Department of Innovations in chemical technologies, master's programs were developed that focused on the development of small and medium-sized businesses in the field of production and processing of polymers produced at the Republic of Tatarstan.

These master's programs "Innovative Entrepreneurship in the Field of Production of Polymer Composite Materials" and "Innovative Entrepreneurship in the Field of Processing of Polymeric Composite Materials" at first, they focused on the training of Nizhnekamsk specialists in the field of chemistry and technology using study on the distance. The purpose of using distance educational technologies was to provide students with the opportunity to master educational programs directly at their place of residence [4, 5]. This training technology operates using various technical means and methods - e-mail, WEB-conferences, personal account, Moodle system. For the correct organization of training, modern universities with distance learning use special software products that, in combination with the capabilities of the Internet, give good efficiency [6, 7]. Distance training programs allow to take a training course "on service". There are ability to engage in a convenient time and place and the ability to apply the acquired knowledge in practice in your organization. Students receive advice from teachers and discuss all issues on the forum in the learning process [8].

The dynamic development of the petrochemical cluster explains the need for advanced training of undergraduates without a long separation from production work. In this regard, the training of masters in the program "Innovative Entrepreneurship in the Production and Processing of Polymer Composite Materials" from among specialists with basic chemical and technological education, while at the same time working in specialized enterprises, is relevant and innovative. The uniqueness of this program lies in the implementation of interdisciplinary training of undergraduates. In particular, the program includes 2 large blocks of disciplines in various parts:

Chemical technology of polymer composite materials:

- Innovative aspects of industrial organic chemistry;
- Chemical technology;
- Promising polymer composite materials;
- Additives to polymeric materials;
- High technology chemical enterprises;

2. Entrepreneurship and organization of small innovative enterprises for the production and processing of polymer raw materials:

- Business planning;
- Economics of a small innovative enterprise;

- Marketing and pricing of chemical products;
- Strategic management of the enterprise;
- Taxation of a small innovative enterprise;
- Economic assessment of investments in a small investment enterprise;
- Project management.

Twice a semester, undergraduates attend lectures and laboratory workshops in Kazan, test modules are delivered remotely. The master's thesis of the graduates of this program is devoted to the technological development and deep economic feasibility of the project in the field of production and processing of polymer composite materials.

2 Assessment of Entrepreneurial Competencies Formation

Interest in these programs was shown not only by manufacturers with basic chemical and technological education in Nizhnekamsk, but also by specialists from other cities and regions. To improve the master's program and understand the profile of students in the program, the motives for their choice, a survey was conducted among 1st and 2nd year students of this master's program. The survey showed that in the groups on innovative entrepreneurship more than 60% of masters is studying, combining education with work. The reasons why undergraduates studying innovative entrepreneurship choose these programs to continue their professional growth were mentioned different.

This program is based on the knowledge gained through undergraduate studies, while adding new disciplines in the field of production and chemical technologies, economics. A student gains high competitive abilities in the labor market. Training in the specialty "innovative entrepreneurship in the field of polymer production" helps to understand the technological processes, which are calculated during business planning. It makes it possible to look at the production process from another perspective.

- the relevance of this sphere in the modern world, a promising direction;
- obtaining new and deeper knowledge in the specialty, self-improvement;
- the need to obtain additional knowledge as in their future work, as for career growth;
- the desire to get higher education and new knowledge, despite the work;
- higher education and practical consolidation of theoretical knowledge;
- the opportunity to improve their knowledge and skills, learn and learn new things, become a high-quality specialist;
- advanced training and the acquisition of new knowledge. The implementation and application of scientific work in practice;
- progressive learning, which combines its own development and professional;
- the opportunity to supplement the program in which economics and polymer composite materials are taught at the same time.

The experimental groups, as the reason for entering the classical master's program, indicated - the desire to continue in-depth chemistry education under the undergraduate program. The further comparative survey involved masters of the first and second courses of "Chemical Technology" and "Innovative entrepreneurship in the processing and production of polymer composite materials" programs.

There were several questions. Question 1: are you able to evaluate the economic efficiency of technological processes? The answers of students presented on the Fig. 1.

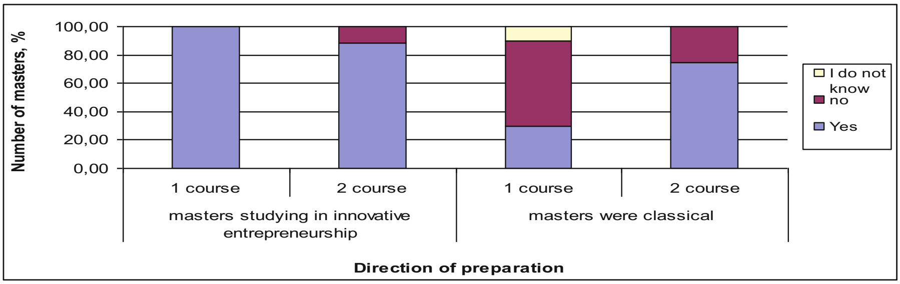

Fig. 1. The ability to evaluate the economic efficiency of technological processes.

Question 2: are you able to assess innovative technological risks during the implementation of new technologies? The answers of students are shown on the Fig. 2.

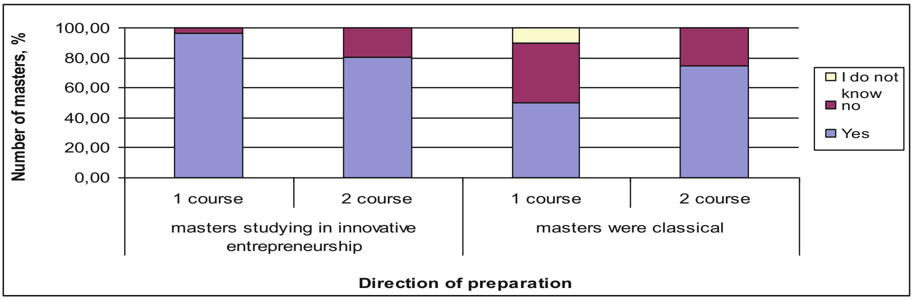

Fig. 2. The ability to assess innovative technological risks during the implementation of new technologies.

The most prepared and confident, as can be seen from Figs. 1 and 2, are Masters studying in innovative entrepreneurship programs. Question 3: Are you able to evaluate the effectiveness of new technologies and introduce them into production?

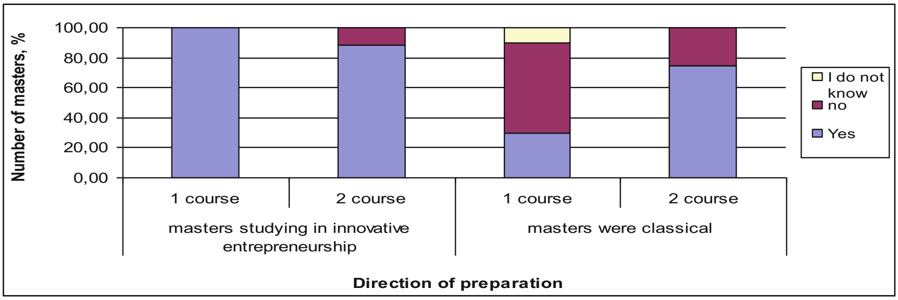

Fig. 3. The ability to evaluate the effectiveness of new technologies

According to Fig. 3, while in the first year students still doubt their abilities, in the second year classical masters look more confident in this matter;

4. Are you able to calculate and evaluate the conditions and consequences (including economic) of the organizational and management decisions?

If you look at the results of the answers received (Fig. 4), then you can clearly see the best situation among masters studying in innovative entrepreneurship. But in percentage terms, 60% of the group of classical masters does not have this competency at the entrance, 35% at the exit, of which it is already formed;

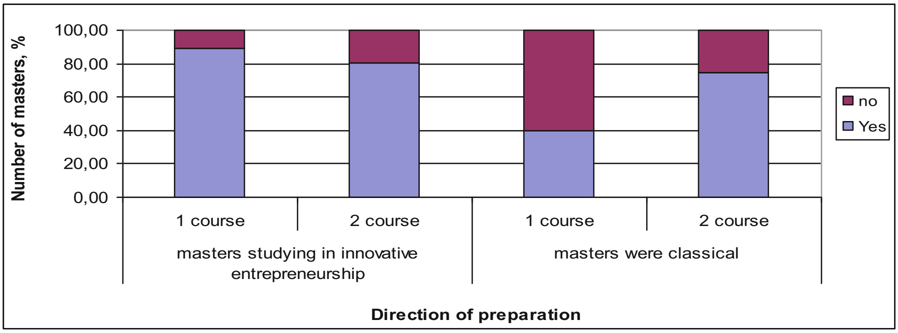

Fig. 4. The ability to calculate and evaluate the conditions and consequences (including economic) of organizational and managerial decisions

The following two questions were concerning of soft skills.

5. Are you capable of organizing the work of a team of performers, making executive decisions in a spectrum of opinions?

6. Are you able to determine the order of work?

We sow almost the same situation: if in the first year, some students of both programs did not have these competencies, then in the second year, masters are ready to organize the work of the team of performers, determine the order of work. Answers to the last two questions concerning of entrepreneurial skills:

7. Are you able to find optimal solutions when creating products taking into account the requirements of quality, reliability and cost, as well as lead times? (Fig. 5);

8. Are you able to conduct market research and prepare a business plan for the production and sale of promising and competitive products? (Fig. 6).

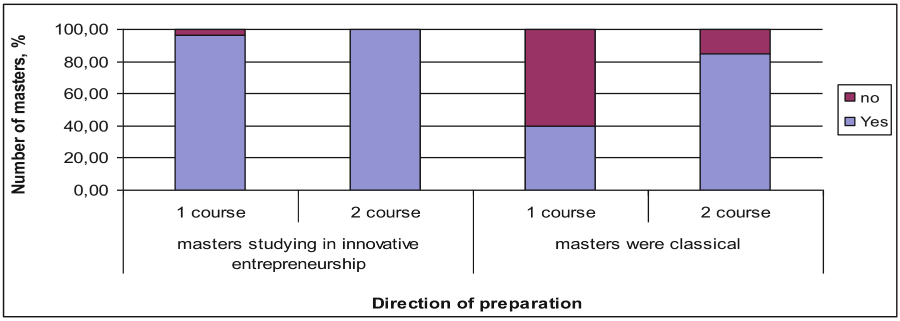

Fig. 5. The ability to find optimal solutions when creating products, taking into account the requirements of quality, reliability and cost, as well as deadlines

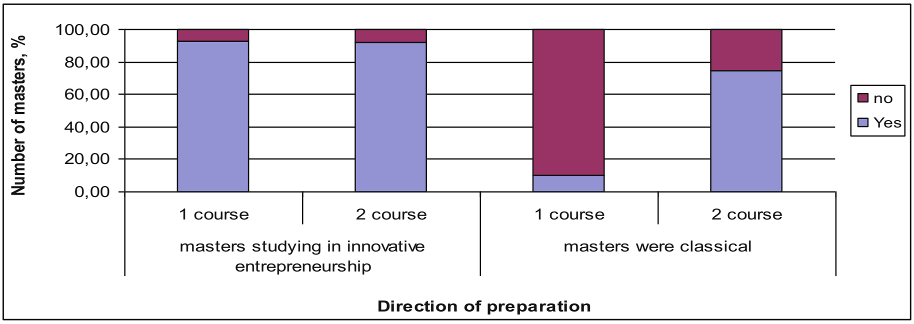

Fig. 6. The ability to conduct market research and prepare a business plan for the production and sale of promising and competitive products

As can be seen from the figures above, Master's degree students in innovative entrepreneurship fill holes in their education. The success of innovative entrepreneurship programs is due to combination of technology and economics: students look at the economy differently and the study of economic disciplines allows us to look at technology from a different angle [9, 10]. Master’s degree students were asked the following questions regarding their opinion on the competencies:

1. The possibility of monitoring and evaluating the competitiveness of business;
2. Ability to design organizational structures;
3. Skills for ensuring commercial and informational security of the organization;
4. Ability to predict business trends in the market;
5. Knowledge of legal issues and the ability to make managerial decisions in the framework of national and international legislation;
6. Ability to define and formulate an entrepreneurial mission;
7. The ability to choose and register an appropriate legal form of business;
8. Skills in financial reporting and accounting;
9. Knowledge of the regulatory framework in the liquidation of ownership;
10. The ability to optimize financial and economic activities by IT

First year Master’s degree students gave the following answers (Fig. 6).

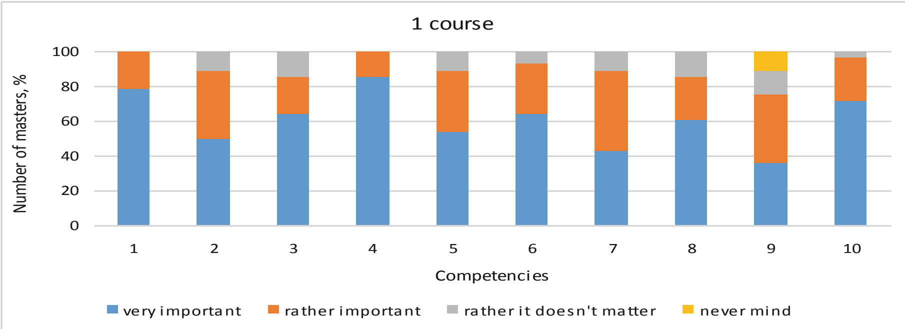

Fig. 7. Necessary knowledge, skills for successful work (opinions of first year students)

Second year Master's degree students gave the following answers (Fig. 7 and 8).

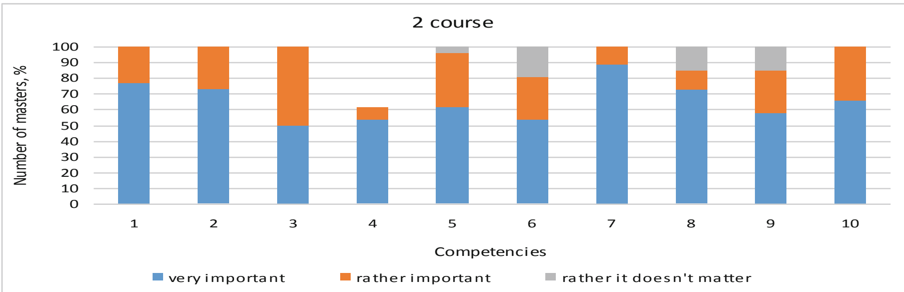

Fig. 8. Necessary knowledge, skills for successful work (opinions of second year students)

As we can see from the answers presented in Figs. 6, 7 masters studying in innovative entrepreneurship are quite demanding. In view of the relevance of this sphere in the modern world as well as the prospects of this direction, they went to this program consciously: to obtain new knowledge in the field of production and chemical technologies, as well as economics that open new horizons for them, they allow themselves to be improved, to realize themselves in a new profession or pursue career growth. Thanks to this tandem, Master's degree students gain high competitive abilities in the labor market. Since this category of students is already working, they know what competencies they need for further successful work [11, 12].

As we can see, for the masters studying innovative entrepreneurship, by the second year, most of the above competencies are formed. Teachers of _ were also interviewed later (15 people participated in the survey). These teachers conduct disciplines of the chemical-technological direction for both masters studying in innovative entrepreneurship and classical masters. Teachers note that at the master's level, information is given on a wide range in the field of chemistry and technology of composite materials, as well as an analysis of the main problems. The training of masters in innovative entrepreneurship is dictated by time and it needs to develop not only new ideas, patents, but also to commercialize them, creating small innovative companies together with students and implementing best international practices.

Most teachers believe that entrepreneurial skills allow graduates to conduct business more rationally and purposefully, focusing on pre-planned results. The presence of these skills significantly increases their value in the labor market. However, many factors influence the decision to start a business. The competencies that graduates of these programs possess are undoubtedly important in achieving this goal.

3 Conclusion

Training in the Master's program "Innovative Entrepreneurship in the Field of the Production of Polymer Composite Materials" and "Innovative Entrepreneurship in the Field of Processing of Polymer Composite Materials" is a system of educational services that can be used by a wide audience graduates. Also, these programs are aimed at ensuring that teachers perceive this training as an opportunity to reveal the entrepreneurial spirit for students to be more entrepreneurial in their follow-up activities. A loyal attitude to innovative entrepreneurship will be the Foundation for the development of its own small innovative industries within the regional polymer cluster [13].

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Digitalization of an Educational Business Model Game

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Abstract. Entrepreneurship Education is an important field of entrepreneurship research and has become a part of many programs of business and engineering schools. Research also confirms that a new generation of learners, the generation of millennials, has emerged that shows a preference for interactive and experiential learning. Contemporary entrepreneurship education follows this approach by including a set of practices where students can explore concepts through personal experience. Educational games are a powerful tool to create such a learning environment. With the goal of investigating digitalization of business games, which are typically played in large groups and face to face, we particularly focus on the use case of the business model game called "inspire! build your business". We give an overview on relevant comparable games, report on our approach for digitalization focusing on our use case, and we address the following research questions: How can the currently implemented game mechanics be improved and what needs to be considered when implementing a fully digital version of the game? We adopt an engineering-based approach, where we build an application for being tested in a heuristic evaluation. The results of our analysis provide motivation to continue the digitalization of our business model game.

Keywords: Entrepreneurship education · Educational game · Digitalization · Gamification · Experiential learning

1 Introduction

According to a recommendation of the European Parliament and the Council, entrepreneurship is one of the key competences for lifelong learning [1]. This advice was a significant impulse for entrepreneurship education to gain importance in Europe, both as a field of research and in school practice. Meanwhile, entrepreneurship education has become an integral part of many programs of business and engineering schools [2]. Research confirms that a new generation of learners, the generation of millennials, has emerged that shows a preference for interactive and experiential learning. Contemporary entrepreneurship education follows this approach by including a set of practices where students can explore concepts through personal experience [3].

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Educational games are a powerful tool to create such a learning environment [4]. They allow the communication of theories and methods in a playful way and encourage students to think and act entrepreneurially. Entrepreneurial games teach how to identify opportunities, evaluate risks, stimulate processes to find ideas for their implementation, and how to test alternative business models quickly. Finally, they are suitable for reflecting on the decisions made and actions taken in the game.

A further trend is the digitalization of teaching and learning. Digital technologies help teachers in various ways because they can reduce paperwork, facilitate the distribution of information, and foster students' empowerment and new forms of interactions. The Corona crisis demonstrated the importance of these technologies for teaching in schools. The benefits of greater integration of digital elements in the classroom enable teachers to provide individualized support to students, which can improve the student-teacher relationship. Spatially and temporally distributed work is also favored. Further, other forms of information transfer, such as short films or quizzes, can be easily integrated into the class and support students in self-directed learning. The diffusion of these new forms of learning is favored because most students already have the necessary digital skills and the required hardware, such as tablets and smartphones.

Within this article, we discuss an innovative business game called "inspire! build your business" [5]. The business model game is designed for high school students as well as university students and encourages them to think and act entrepreneurially. It aims to increase their awareness, motivation, and skills for entrepreneurship. Initially, it was a physical board game. Triggers for the development of a hybrid game version were barriers in the school environment as well as the needs of potential users. Schools often do not have the necessary space, tools, and resources to use this learning game with distributed roles and activities. Digitized game elements make it easier to implement the distributed work of students required due to insufficient space. Digitization also enables more cost-effective updating of teaching materials, including new case studies. Fewer paper copies are also beneficial in terms of resource conservation. Teachers who used the game in their class expressed the wish that they would prefer to use the time they need to distribute and organize materials to coach the students during the game. The digital version also facilitates the further training of teachers, who have the role of coaches and instructors in the game. New game variations and innovative case studies or instruments can be offered more easily in the form of videos or webinars. In this way, they expect a higher efficiency and effectiveness of teaching.

In the paper, we report on the first stage of digitalization and discuss early reception based on a heuristic evaluation with experts assessing the approach. With the overall goal of investigating the (partial) digitalization of business games, which are typically played in large groups and face to face, we particularly focus on the game "inspire! build your business" and with a heuristic evaluation addressing the following research questions: How can the currently implemented game mechanics be improved? What needs to be considered when implementing a fully digital version of the game?

2 Games in Entrepreneurship Education

Prior research supports that games, simulations, and gamification techniques promote learning and that they are powerful tools to create a motivating learning context [6–9]. Business games and simulations have a long history in business education, dating back to the year 1956. Whereas early business games were hand scored and based on classroom activities, recent games use increasingly digital learning environments [10, 11]. Within our literature review, we are especially interested in games within the context of entrepreneurship education. Belotti et al. (2014) investigated serious games adapted in higher business and entrepreneurship education in Europe. The analysis of 11 serious games shows that most of them simulate small business management, but there are hardly any, which emphasize on innovative product and service development [12]. Fox and colleagues (2018) also reviewed eight serious games in the context of entrepreneurial learning. They confirm that the reviewed games mainly focus on small business management. Issues such as opportunity recognition, the early stage of venture creation or venture investment are not incorporated in the simulations [11].

Our review of entrepreneurial games also included non-digital games or hybrid games. We confirm the previous results that the games simulate the launch and management of a small business. We identified two games that focus on business model development. However, business ideas are mostly simple and have a low degree of innovation (Table 1).

Table 1. Updated and extended review by Krajger and Schwarz (2019), [13]

Author	Game	Main features	Implementation
Lai and Siau (2003), [14]	EBiz	In this online competitive business game students take different roles in a small business company. They compete and interact within a simulated business environment. The winning team is that with the best performance in terms of profit, market share, plant capacity, etc.	Digital
Murff and Teach (2009),[15]	Entrepreneurship	This is a computerized non-competitive business game which can be played as a single person or as a single team. It starts with the presentation of a technology-based product concept and simulates the first five years of a technology-based firm. The key element of the game is a repeating decision cycle	Digital
Zapata-Tamayo and Zapata-Jaramillo (2015), [16]	Building social communities	Each player will have a specific number of puzzle pieces which belong to different puzzles. The goal of the game is to create a community by solving the puzzles	Analog
Shankar (2016), [17]	UDAN	Participants represent start-up teams who have to allocate resources effectively and efficiently by managing the different airport industry stakeholders. Other participants represent different industry and governmental stakeholders	Analog

(*continued*)

Table 1. (*continued*)

Author	Game	Main features	Implementation
Wittenzellner et al. (2016), [18]	SysTeamsRybi	It is a board game, where participants develop in eight steps a business plan for a business idea	Analog
Kriz and Auchter (2016), [19]	Top Sim Start-up	This computer-supported business game simulates the different stages of a start-up business, including information collection, evaluation of the business concept and idea transformation	Hybrid
Laurischkat and Viertelhausen (2017), [20]	Business Model Gaming	This physical board game simulates a four-stage business model innovation process in the field of e-mobility. Participants assume the role of basic stakeholders in that industry	Analog
Oliveira et al. (2017), [21]	Formula E^2	In this serious game, competing teams have to manage a virtual company that manufactures a unique product	Digital
Alves, Cabral (2018), [22]	Venture Capital Game	Players have to take the role of potential investors and have to evaluate start-ups and to develop a start-up portfolio	Analog
Faltin (2018), [23]	Brains and Capital	In this board game participants compete in teams and develop based on mission cards an idea. The winning team is selected by participants voting or by a jury	Analog

3 The Game “inspire! Build Your Business”

The business model game “inspire! build your business” is based on a four-stage stage-gate process [5, 24, 25] which integrates central principles and practices from Open Innovation [26] and Lean-Start Up [27]. Milestones separate the four stages from one another. Predefined criteria at each gate help to evaluate the business idea. A decision has to be made if the process should be continued, stopped or the business idea should be modified. Each stage consists of three steps (Create - Test - Improve) and integrates the principles of experimentation, validation, and testing (Lean-Start Up approach).

From a didactic perspective the game follows the practices of entrepreneurship developed by Neck et al. (2014), by combining play, experiential learning, feedback loops, and self-reflection [3, 28]. It is entrepreneurial in that the game is based on real innovative business ideas. Students have to evaluate the business idea, gradually develop a business model and present it three or four times to potential investors. Currently, three versions of the business model game exist. The intended pedagogical objective becomes increasingly complex depending on the target group addressed, ranging from secondary school students to students in bachelor and master programs [13, 29]. Students compete in teams of five with a maximum of 25 participants.

Every version follows the classic sequence of a business game [30]. Inspire! build your business includes a briefing session (which can be prepared in advance or in another lesson), three or four playing rounds and finally a debriefing. The debriefing includes a reflection with a comprehensive generalization in the sense of experience-based learning according to Kolb (1984) [31]. In this paper we focus on the game version for high school students. Within this setting, the business model game ends at stage 3 and lasts one day.

The game inspire! build your business builds upon the following game elements (Table 2). Initially, designed as a rule-based physical board game, the first step of digitalization combines the board with a web application and support videos.

Table 2. inspire! build your business: game elements and their implementation.

Game elements	Implementation
Onboarding	Group building exercise, team construction mini game
New identities & roles	Play the role of an entrepreneur, case & role cards
Simulating entrepreneurial ecosystem & unpredictable constraints	Dice & game cards
Challenges and quests	Challenge cards
Progress	Game Board and moving game pieces
Competition and cooperation	Pitch (of the other groups), teamwork
Immediate feedback	Pitch & jury, scoreboard
Freedom of choice	Develop, design and pitch a business model, game cards
Time restriction	Limited time resources are a key mechanic/principle
Knowledge transfer	Method cards and explanation video

To get an impression and to understand the game design principles, we describe the beginning and the first playing round (see Table 3) of the game. The game starts with an introduction to the game rules, a time outline and a short video about the business model development process. The participants decide on one business idea with five people per idea. As a warm-up a small team building exercise takes place. The teams get a case card that describes a real business idea and a role card, which helps them to take the role of the founder or entrepreneurial team. The descriptions should give the players enough challenge without overwhelming them. Every team gets start resources in points by rolling the dice. This step simulates that founding teams start with a different set of resources.

In the first playing round participants are confronted with opportunities and risks of business model development. A short explanation video introduces the theoretical concept behind. Randomly distributed game cards (by dice) simulate these factors and show that entrepreneurial action is embedded in an environment and stakeholders play an important role. The teams conduct an opportunity analysis by receiving a method card and they prepare an elevator pitch and present their idea in 60 s to potential investors. The teams get immediate feedback on their presentation and receive points from the jury. Teachers from school or external judges can take the role of a potential investor. The last challenge of the first playing round is a short creativity session based on the principles of the game "Activity". Teams draw cards randomly with terms from the field of entrepreneurship. They are challenged to explain the term by drawing, presenting or describing the term to their team. If the team is successful, they receive points. The following playing rounds follow the same game design principles.

Table 3. Timeline of the first playing round

Timeline: briefing and first playing round	
30 min	Introduction to the game and business model process by explanation video
20 min	Team building
15 min	Simulation of risks and opportunities (by dice); explanation video
60 min	Opportunity analysis
15 min	Elevator pitch
15 min	Challenge zone: "Activity"

The instructor's role is to brief the students, execute the digital distribution of cards, play and comment on the explanation videos, and coach the students through the process. The instructor is responsible for keeping the timeline and has to make sure that the teams apply the proposed method cards correctly.

4 Methodological Approach and Digitalization

We largely follow the methodological approach from Denning et al. (1989), which states that research should follow four steps, being (i) definition of objectives, (ii) building a hypothesis, (iii) testing the hypothesis, and (iv) interpretation of results [32]. We outline the four steps as well as our approach in Table 4.

Table 4. Our approach following the structure from Denning et al. (1989).

Step	Our approach
Definition of objectives	Reduction in the workload of the game instructor and increase in the quality of experience of the players
Building a hypothesis	Digitalization of parts of the game helps the game instructor to focus more on support of the players
Testing the hypothesis	Partial digitalization of the game focusing on tracking the game progress and score board and heuristic evaluation
Interpretation of results	Discussion of the heuristic evaluation with focus groups and experts and formulating a collaborative report on the evaluation, which is then discussed with the stakeholders of the game

The overall objective is to reduce the workload of the instructors as well as to increase the quality of experience for the players for the game inspire! build your business. Instructors typically have to take care of many things at the same time, including instructing players, managing content distribution between groups, helping when problems arise, and tracking the game progress. Players on the other hand naturally have questions and have to queue to ask the game instructor. We hypothesize that if we start with the digitalization of scores and content, instructors can focus more on moderation of the game. As an effect, players get more attention and have a better experience.

We use an engineering approach for testing the hypothesis. We implement a web-based application to support the game instructor and to distribute the content to the teams. Team scores are tracked within the application and access to all material for the game is published in a way that players can access all of it with their mobile phones. With a heuristic evaluation, we evaluate our approach. Graduate students, who are at the time of the study enrolled in a master's program on game studies and engineering, serve as expert users as they can employ their knowledge from game studies and game development to assess the application and its impact on the game itself. As students of game studies and engineering they build their knowledge on technical as well as social and cultural sciences and can view the game through multiple lenses. Focus groups reflected on the game and the players' experience before and after the heuristic evaluation and a collaborative report was created. An additional benefit was that the master students were not older than 25 years, so their school experience is still fresh. Finally, we discuss and interpret the feedback from the evaluation and derive the next steps.

With the original game running as a moderated and analog business game with additional board game elements, we decided to aim for an implementation that supports a hybrid game, partially digital, partially analog. Our implementation is based on a responsive web application, which can be accessed by players and instructors through a wide range of devices, including mobile phones, tablets, notebooks and desktop computers (see Fig. 1). Access control as well as content release for different stages of the game is managed by the instructor.

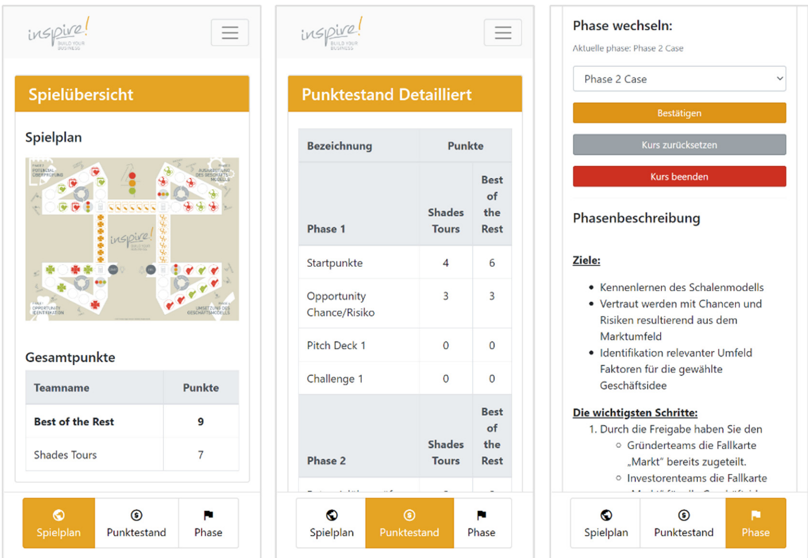

Fig. 1. Screenshots of the web application. Currently the application only has a German interface, but translation is planned for the next steps.

5 Heuristic Evaluation of the Game

The evaluation of the game includes the assessment of the application and its impact on the game itself. This includes the analysis of game balancing, luck as a game element, self-informed decision making and choices within the game, transparency of rules and processes, crunch time as core concept of the game, and communication between judges, moderators and teams. Our experts for the heuristic evaluation were recruited from the master program game studies and engineering. 18 students (12 male and 6 female) attended a session before the game, where an overview on the game was given and the evaluation method was discussed. The experts were asked to build groups around the following topics:

– Game balancing and luck as a game mechanic
– New game mechanics
– Interactive tutorial, teach the teacher, game master support
– Gamification and digitalization

Note at that point that the experts understood game mechanics as interaction elements for players, that in cumulo make up the game play. That includes dice rolls, drawing cards, moving pieces on a board, but also on high level pitch decks and communication tasks. Each focus group was encouraged to take a detailed look on their own topic while playing and to take notes on observations. Five days after the game play an additional reflection workshop took place. The experts were asked to discuss their notes in the focus groups and summarize the points noted in a collaborative document. The points were then discussed and detailed by all experts. In the following two weeks experts could add to or update the collaborative document, which was done by eleven experts. This resulted in six written pages of reflections on the game in the mentioned topic categories.

For game balancing and luck as a game mechanic, the focus group identified fairness, transparency and clear rules as a main issue. Those points are interconnected as decisions of the instructors should be transparent and well documented in the web application. Moreover, the rules for the particular tasks should be made explicit in the app. According to the experts, the scoreboard should feature a higher level of details. An example for such a case is the score awarded by judges after the pitch. Experts asked for a detailed description how each of the judges awarded the points instead of results averaged over all judges. In addition to that the experts collected detailed comments on the nature of challenge cards, tasks and the scoring system.

The new game mechanics topic showed possible directions for future development of the game. One main point was that resources that can be spent and earned by the players would allow players to decide on how they approach problems. Judges could be the ones awarding money, which could then be spent by the players. The complete removal of the game board as well as the dice rolling phase was discussed and the introduction of personas for judges and economical context, i.e. market situations, was mentioned.

For the game start the experts recommended an interactive tutorial, which could also feature pre-recorded sessions and best practice examples. Moreover, the experts recommended a shorter feedback loop on a team level. Teams should be given explanations on what they did well, and what not and their achievements should be put into context of the educational aspects in the feedback loop as well.

For digitalization the experts noted problems when using the system. For instance, the accuracy and timeliness of the scoreboard was criticized, as there were bugs with the automatic score update and the way the instructors update the scoreboard was deemed complicated and cumbersome. The accessibility of the provided content was a topic as the web application on mobile phones was perceived confusing and overwhelming for some players. Moreover, experts outlined the benefit of textual and multimedia content within the app in contrast to PDFs that have to be downloaded. For gamification a lot of creative new directions were pointed out. First of all the app should play a more important role, by providing additional information like (i) judge profile showing their preferences and expectations, (ii) achievements for completed tasks, (iii) featuring a collaborative white board, and (iv) by offering previously recorded ghost sessions as examples or virtual competitors. Furthermore, experts mentioned that resources that can be spent throughout the game (money, points, etc.) would be beneficial to allow more control over the game to the teams, and the pitch phases should include more game-like elements.

6 From Partial to Full Digitalization

Recent developments and the current situation around Covid-19 have shown that in general digital literacy has increased and the society is ready for digital gatherings and over-the-network game playing. Instead of social gathering, which were not allowed in many countries for an extended period, people played games, which they traditionally played as board games or gathered around a table, over the internet. While single games are implemented as computer games with network aspects, like Uno, Monopoly, Risk or Catan, others were made available by the community, like Backgammon, Chess or Rummy. A specialized tool for playing games online together is Tabletop Simulator. Each player must install the software, but then a multitude of games can be played within the tool, which basically provides a table and common game elements like cards and dice. While some of the games are ready to use, like for instance, Chess or Solitaire, provided by the developers of Tabletop Simulator, others are adopted for Tabletop Simulator by the community by adding cards, boards, and other game elements, and implementing rules.

With the prospect of making our game digital tools like the tabletop simulator already offer a way to use existing, well working software to support digitalization. However, for our game the communication in between teams and the creative space has been a core component up to now and, therefore, communication software is another option to use for the game. While game elements are not directly supported, group chats and calls, screen sharing, and collaborative documents are provided and cover the communication and co-working aspects of the game. Possible options include, but are not limited to Discord, Zoom, and Slack. Each of them stands for a category of communication software and has its unique abilities and constraints. All three of them would - in principle - be able to serve as platform for our game, but game instructors might have extra work with communication moderation, helping players to use the tools and fill the gaps with external tools, e.g. a white board for Discord, or organizing break out rooms in Zoom.

7 Summary and Outlook

The overall feedback provides motivation to continue the digitalization of our business model game. While the experts uncovered inconsistencies and conflicting details, they mentioned that the educational purpose of the game for them is comprehensible and understandable. They further encourage to rely on extensive user feedback and user studies. With the first digitalization stage, instructors are supported in organizing and distributing materials, but this can further be simplified. That would allow them to focus on their role as coaches to guide the players through the game. A further step of development could be the integration of multimedia content (e.g. videos) and more interactive elements in the application, especially for the onboarding in the form of interactive tutorials. Potential also exists in applying additional game mechanics such as timekeeping and resource management to further improve user experience.

Feedback showed further that although the digitalization was kept on a small level, common software development problems reduced the usefulness of the application. Quality assurance methods have to be implemented in the development process, like bug tracking, unit and interface tests and focused user studies to make the interface more intuitive and useful. The level of detail regarding the information available for the players, however, requires additional evaluation. While the experts agreed in the reflection workshop on more information is better for transparency and fairness, they noted that the information already available overwhelmed them. Additional studies should make sure that the interface of the application is intuitive, provides the information needed in a context sensitive way, and offers additional information on request.

For now, we decided to follow the track chosen with the hybrid version and digitalize further along the lines we anticipated: reducing the amount or organizational work for the instructors and administrators by distributing content digitally, and managing the progress of the game in the app. Additionally, as a result from the experts' comments we will incorporate an additional feedback loop on the usefulness of the app by players and instructors. However, with the acceptance of video communication software and digital collaboration suites, the game can be levered to a fully digital version.

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Project-Based Learning Activities for Engineering College Students

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Abstract. The paper discusses the effective organization of students' project-based learning activities in an engineering university. The educational process modernization involves the introduction of new teaching approaches related to the development of additional competencies of students which allows them to implement complex projects, consequently increasing the competitiveness of university graduates in Russia. Numerous studies on project-based learning show it as the most suitable means of achieving effective competence-based education. The research proposes that the dissemination students' project-based learning activities in an engineering university will be effective when the following pedagogical conditions are implemented: targeted development of students' project-based learning activities; using student-student interaction in the students' project-based learning activities; the readiness of the university faculty to organize and implement students' project-based learning activities. Criteria for students' project-based learning competencies are basic and in-depth knowledge in engineering field; professional competencies and personal qualities, interpersonal skills, ability to initiate, develop and implement projects. The paper is based on some successful examples of effective projects done by engineering students.

Keywords: Project-based learning · Engineering university · Team projects · Research skills · Engineering student

1 Introduction

1.1 Relevance of Study

Innovative development of an engineering university requires determining priority areas and the change in curriculum with the inclusion of project-based learning activities based on the integration of experience, practice and theory. Our study involves improving the implementation of resource tasks, deepening creative and informational competencies, predicting the nature of activities results, as well as the ability to collectively and individually solve tasks. Educational potential of project-based learning, developed at McMaster University in Canada in the late 1960s, was studied by number of international and national researchers. Many researchers paid attention to the implementation of project-based learning in engineering education [2, 4, 9]. Some Russian studies have proposed project-based learning as the most suitable

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means of achieving competence-based education [1, 14]. A series of researches looking at best practices of active learning methods was done by our University professors [5, 6, 10, 12, 13].

However, the approaches to the organization of these activities in the educational process of the university are not sufficiently proposed. In the systematic review of our research, we came to the conclusion that the most effective approaches for project-based learning in engineering education are the application of the STEM concept; development of student's meta-subject competencies in additional educational programs; readiness of educators to develop project-based learning activities among engineering university students.

1.2 Approach

In our study, we used an analytical approach, which helps to develop students' project-based and creative skills, their engineering competencies which determine innovative solutions in engineering based on the analytical abilities of students. The materials and methods of our research are based on the inter-cycle integration paradigm, which is determined by the emergence of new properties of project-based learning system and acquisition of engineering competencies by students.

2 Problem Description

Students' project-based learning in an engineering university is connected with the need to develop engineering skills and professional competencies. Students carry out integrative projects by analyzing engineering products, mathematical and engineering subsystems, as well as identifying problems taking into account different educational standards. Project-based learning is an activity related to the use of professional knowledge in the context of phased problem solving which develops creativity and creative thinking [11]. It is based on control and measuring skills, studying the starting systems of the engineering industry, applying knowledge regarding the implementation of an integrated approach in the context of professional integration knowledge and socio-creative problem solving. S.V. Matveeva notes future engineers' project-based activity is associated with the search for independent solutions, in managing engineering risks, predicting the nature of the results in laboratory tests. The author emphasizes the ability to collectively and individually solve the tasks [8]. Engineering competencies and personal qualities of students are associated with the ability to analyze research results, apply the integration of forecasting and scientific synthesis of the tasks in the system of information retrieval and use of multimedia.

We believe that the success of project-based learning activities in an engineering university depends on the quality of students' research work, the use of correlated engineering developments, and modeling of projection systems that allow them to realize creative skills. Participation in educational research should perform the following tasks:

- application of innovative technologies and engineering inventions;
- implementation of project results and their practical application on the basis of systematization of the basic foundations of engineering;
- a clear focus on modern engineering technologies to improve the project quality, and its purpose;
- integration of knowledge from various fields of science, engineering, technology, creativity, economics, production, production automation control systems, management processes;
- the study of the problems of project-based learning activities taking into account their leading nature, the methodology of the experiment, search information activities, laboratory work, the study of theoretical and practical material.

The ability to explain the nature of ongoing engineering processes in engineering students' project-based learning activities is associated with increasing scientific competencies based on students' cognitive skills. This is due to the increase in intellectual activity, as well as the student's ability to set goals, the skills of compiling project documentation and reports, the ability to structure the material and in delivering presentations.

In our opinion, in order for specialists to be competitive, it is necessary to create conditions where the research activities of students in project-based learning are associated with the solution of intersectoral problems and economic calculations that form applied knowledge in terms of the effectiveness of independent work. An important area here is the implementation of the STEM approach, where subjects are studied using interdisciplinary training based on problematic tasks, integration of tasks by modules, complexity of resource knowledge and creative application of universal educational standards. The goal of STEM education is to prepare students for a more effective application of acquired knowledge to solve professional problems [3]. Moreover, according to I.A. Komarova, the focused work of future engineers should include the design and improvement of technical systems in applied engineering areas, a spatial and analytical approach to project implementation, as well as supporting design and research sites of STEM clusters [7]. We believe that the use of the STEM concept in additional educational programs allows students to design project-based activities based on the integration of the principles of consistency, variability, problematicity, creativity, and co-creation. The prevalence of a multidisciplinary approach allows students to apply their knowledge to solve technological problems, develop technical abilities and critical thinking skills. The training itself is built on the basis of problem-oriented educational activities (based on projects and technical design), which combines scientific principles, technology and design. The development of the ability to generate new ideas, the ability to draw analogies, solve problem-creative tasks and develop the competencies of supra-situational thinking contributes to the development of students' creative skills. The information environment of the university creates the conditions for the development of design and research competencies of students, for example, participation in national and international conferences and competitions, field trips to industrial enterprises, participation in hackathons, case championships, engineering slams, master classes, seminars with university professors and foreign partners.

The development of continuing education programs for university teaching staff to form readiness for professional pedagogical activities in the field of project management in education is of particular importance for engineering students' project-based activities.

3 Research Results and Discussion

As mentioned above, the ability to generate ideas and analyze projects with innovative potential, to determine the strategic goals and objectives of the project must be developed on the basis of integrated forms of training and development of projects of a leading type.

We have developed an additional educational program for A-level engineering university students in the field of innovation and technology project management, focused on the application of the STEM approach in education. The program allows us to use integrated forms of training associated with different tasks and their step-by-step solution using search and information skills in the system of intersubject communications. It is very important to form innovative engineering thinking among students, which is aimed at implementing technical and scientific projects through the integration of academic and acquired knowledge, as well as developing meta-subject skills in solving financial, engineering, material and technical, methodological issues in the development of the project.

Under the guidance of the university faculty, students develop team projects based on their major. In addition, participants in this program also take additional modules for in-depth study of specialized disciplines, information technology, and modules on the theory of solving inventive problems, entrepreneurial activity, project management, and become participants in training sessions to improve communication and personal skills.

Students' project-based learning is supported by university information environment. Students traditionally participate in the All-Russian competition of youth innovative projects "UMNIK", the competition "50 best innovative ideas for the Republic of Tatarstan", the International Engineering Championship CASE-IN, the Republican industry competition for innovative projects of young scientists "Science and Business" and other competitions. They learn to analyze and study the most important problems of using modern engineering technologies, creating hardware systems in a non-profit partnership system. So, in 2019, projects of students participating in an additional educational program in the field of managing innovative technological projects became winners and finalists of the UMNIK contest.

The most significant ones are the project for the purification of water from a petrochemical industry by the filtration-sorption method using modified fruit shells of barley grains; a project to develop a neuro-regulator based on an artificial neural network for regulating and modeling technological processes; a project to develop a mobile application with the routes to all the University buildings; a project to develop environmentally friendly diesel fuel and others. Students of the program became participants in the annual summit of young scientists and engineers "Big Challenges for Society, State and Science", held in Sochi. In 2020, students became finalists of the

CASE-IN International Engineering Championship, taking 1st place in it, as well as participants in the All-Russian contest of youth independent projects and projects in the field of education "My country is my Russia". Students are also active participants in the All-Russian forums and conferences on innovations in the field of chemistry and chemical technologies.

We diagnosed project-based learning and research skills of engineering students on how they solve project-based tasks of various difficulty levels in the first and second years of study being involved in additional educational program in the field of innovation and technology project management (see Fig. 1).

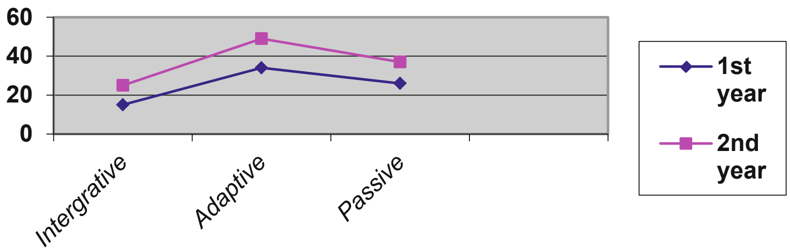

Fig. 1. Diagnostics of project-based and research skills of university students – participants of the additional educational program in the field of innovation and technology project management (1st and 2nd year)

This figure shows three levels of engineering students' project-based skills: integrative, adaptive, passive. They are students enrolled at the program in the field of innovation and technology project management. The integrative level is associated with the ability to work on a problem, search and information skills, the ability to use constructs of creative non-standard thinking, the ability to generate ideas, make independent decisions. The adaptive level is associated with skills in working with computer engineering programs, developed spatial thinking, concentration, punctuality, and the ability to analyze innovative projects. It also measures active participation in scientific and practical conferences, seminars and round tables, developed critical thinking, analysis of texts by searching and selecting information, comparing different opinions, facts and their interpretations. The passive level is associated with the ability to gradually structure the material, analytical thinking, the ability to work in a team, and systemic basic knowledge of engineering. As you can see, the indicators of students' project-based skills are higher in the 2nd year of study in an additional educational program.

The integrity of the engineering training system is a source and driving force for the development of students' project-based skills. Research and innovation here is based on the ability of students to determine the strategic goals and objectives of project products, analyze their results, predict and evaluate the consequences of their decisions. The systematic nature of the educational project is connected with the choice of educational concepts set with a structure, a scheme, methods, and rules necessary for performing specific tasks or groups of tasks. Structuring the project in this case contributes to the formation of universal abilities and skills among students.

For example, a project to develop a pharmaceutical substance based on 3-hydroxy-2,4,6-trimethylpyridine with organic acids and their derivatives is a plan for the synthesis of a pharmaceutical substance that surpasses all available analogues in terms of potency. During the work on the project, students studied drug market, synthesis schemes for analogues of this substance, potential buyers' market, calculated the approximate cost of the study, determined the key phases of the project, its participants and their responsibilities, and compiled a schedule for the project. The project of students to develop a mobile application with the routes to all the university buildings was developed as part of the Smart University project – a university, which provides access to training for everyone, including students with disabilities, universal optimization of the educational process, simplifying the interaction of "student-teacher". During the work on the project, students studied its characteristics and advantages, analyzed trends in the industry, investigated a sales market, drew up a marketing plan, selected the premises for production, found equipment and raw materials, calculated the cost for the application and its maintenance, identified key phases of the project, participants and their responsibilities, and made a schedule for the implementation of the project.

The implementation of project-based activity involves the following areas: strategic engineering initiatives; research and constructive thinking; engineering reflection; innovative engineering competencies; information searching skills; work with program documents; innovative economic knowledge; integration of research, scientific, practical and applied, creative, analytical and constructive skills (see Fig. 2).

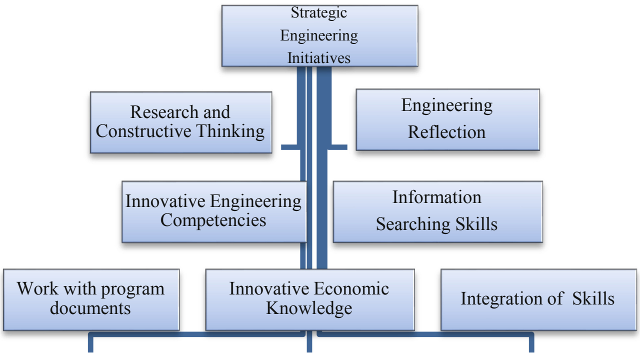

Fig. 2. Project-based learning activities of engineering students

Important attention in project-based learning activities is given to strengthening cooperation with enterprises. As part of the internships, students have the opportunity to learn more about the operation of production lines; they can study the automation of production processes, master product testing, and increase their motivation to acquire professional knowledge. Students also develop practical skills in university educational and scientific centers with experimental facilities.

Another promising area in project-based learning is the formation educators' readiness to carry out effective professional activities in the field of educational project management. For this purposes we have developed a continuing education program for educators in the field of project management in education. The task of the program is to form a set of special knowledge, skills, which ensure readiness for organizing effective activities in the field of educational project management. The results of the program showed an increase in the ability of educators to evaluate innovative approaches in the training of students; readiness for the search, processing, analysis and systematization of scientific and pedagogical information on problems in the field of project management in education; ability to apply project management methodology in the field of education, initiation, development and implementation of projects; ability to use information and communication technologies in project management; ability to implement effective communications in the management of educational projects, as well as the use of technologies, methods and means of managing project resources.

4 Conclusion

We came to the conclusion that project-based learning activities implemented in Kazan National Research Technological University can be considered effective if they meet multifunctional creative criteria, flexible knowledge associated with the constant switching from one aspect to another. During the implementation of these activities we created the following pedagogical conditions. The first one was targeted on the development of students' project-based learning activities when students enrolled in a three-year additional educational program in innovation and technology project management. The second condition was implemented during student's team-based projects (depending on major they declare) under the guidance of university professors, these activities were based on interaction, self-education, self-development and creativity. During the study, there was an increase in students' interests in research, professional activities; we observed effective teamwork and research projects with participation at international competitions. In order to implement the third condition we developed a teacher training program on Project Management in Education aimed at forming competencies necessary for professional pedagogical activities in the field of educational project management.

We assume that further work on organization and dissemination of students' project-based learning activities will contribute to the formation of additional competencies which are necessary for innovations in engineering and complex projects to increase the competitiveness of engineering graduates in the labor market.

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Professional Development of Financial Managers

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Abstract. National economies impose new challenges on training competitive professionals who can succeed in high performance jobs. Financial management is one of them. This business demands professionals with innovative competences, and universities are responsible for training them. Professional development for financial managers, however, received little attention in recent publications. To bridge this gap, the article draws on the results of investigating the curricula for financial managers in universities. The paper aims at defining the theory and methodology underlying the professional development of financial managers and exploring the necessary changes to be introduced in the educational process, its content and forms. The following factors influencing the professional development of financial managers: awareness of personal psychological and physiological characteristics and capabilities, conscious professional choice, adaptability to university and profession, willingness for life-long learning, readiness for changes in profession. Based on these factors, the authors identified the following standards for the content of education for financial managers: student-centered approach to teaching management, marketing, human relations, entrepreneurship and business skills; project-based approach to teaching applied skills through real-world practice; close collaboration between the universities and employers. The survey results showed that the skills formed in university degree programs influence the professional development of financial managers and improve the competitiveness of the graduates. The survey revealed the basic competences of financial managers, including the innovative competences based on the professional standards and market demand. Further research can be aimed at developing special professional development programs for financial managers based on these findings.

Keywords: Financial manager · Professional development

1 Introduction

Professional development is a lifelong process starting from setting the career goals and finishing only with the end of the working practice. Throughout this process, employers and employees are ready to invest in different professional development programs and trainings as capital aiming to enhance credibility, job security and employment prospects. Recent research shows that professional development contributes to individual

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growth and empowers the individuals to use all their potential to the benefit of the society [1, 2].

Academics who investigate the issues of professional development build diagnostic and prognostic prediction models and distinguish different stages of this ongoing process [3]. Although there is no single classification of these stages, in general, they can be summarized as follows:

– choosing a profession and setting preliminary professional goals (high school period);
– obtaining professional degrees (college or university);
– professionalization as gaining practical and professional experience (starting a career);
– proficiency as high-quality creative approaches and an individual style in professional activities (continuing career).

Every stage of professional development of any individual leading to his professionalism [4] implies factors and barriers related both to individual perceptions and labor market conditions [5]. By enhancing these factors and overcoming barriers, universities can train competitive professionals who can succeed in high performance jobs.

Recently, there has been a lot of research done regarding professional development and professionalism to meet the global challenges of the 21st century [6]. The topic is of primary importance in different spheres, including engineering, pedagogy, medicine, and etc. [7–9]. The significance of this topic for higher education is enhanced by the internationalization trends including the Bologna process [10].

Financial management is another important sphere of national economy. It is a complex and dynamic business exposed to many risks under adverse circumstances. This business demands professionals with innovative competences, and universities are responsible for training them. Professional development of financial managers, however, received little attention in recent publications. To bridge this gap, the article draws on the results of investigating the curricula for financial managers in universities.

A financial manager is responsible for maintaining the financial stability of the company, making decisions regarding the future of the company, its financial assets and investments [11]. The following spheres refer to their activities including:

– enhancing the performance indicators based on infrastructural assets and public private partnerships [12];
– finding balance between the internal and external funds, raising additional funding from different sources [13];
– communicating between different groups of professionals, both financial managers and engineers, from the local and international communities [14]

The paper aims at defining the theory and methodology underlying the professional development of financial managers and exploring the necessary changes to be introduced in the educational process, its content and forms.

The study reveals the laws, benchmarks and indicators used to evaluate the success in professional development of financial managers. Therefore, the objectives of the study are:

– to reveal the social, economic and pedagogical factors which influence the professional development of financial managers;
– to define the structure, contents, benchmarks and indicators used to evaluate the professional development process;
– to find approaches to professional development of financial managers who study in Management and Financial Management degree programs.

2 Methods

The authors used theoretical methods of research including the analysis of recent publications in research journals and conference proceedings on stages of professional development of financial managers, including the earliest stages of choosing the future profession going further on to the college or university programs and early career stages.

Apart from recent publications, the authors used their personal experience of teaching courses and individual communication with students and professionals, and the attitudes towards professional development of financial managers they expressed explicitly or implicitly.

In order to evaluate the professional development process, the authors used practice-oriented research through doing a survey among graduates of engineering universities running programs in financial management for engineering enterprises in the period between 2018 and 2020.

The survey involved professionals with Associate, Bachelor's and Master's degrees in financial management so as to analyze the circumstances and criteria which influence the successful professional development of financial managers. The survey included questions about the circumstances which influenced the choice of respondents to be financial managers and to continue their professional development. The validity of the questions was verified and they proved to be well-founded.

The survey included the following blocks of questions:

– yes/no questions regarding the career in financial management or other fields;
– yes/no questions regarding the respondents' attitudes towards the university where they studied;
– yes/no questions regarding the impact of education on their career and quality of education that they received;
– Likert scale type questions regarding the influence of the university environment factors on their successful education, including university equipment, library, teaching quality, administration quality, individual characteristics of peers, learning outcomes assessment, use of computers, efficient educational technologies;
– Likert scale questions regarding the quality of academic courses taught and their impact on career success including management and leadership courses, entrepreneurship and communication courses, financial courses;
– open questions regarding the academic courses that could be added to the curriculum and professional development programs necessary at the present stage of their careers.

The survey results showed the factors influencing the professional development of financial managers and the demand for these professionals in the market. The survey results were compared to the demands of regional engineering enterprises.

The results of theoretical and empirical analysis were summarized and used to define the structure, contents, benchmarks and indicators used to evaluate the professional development process and to find approaches to professional development of financial managers who study in Management and Financial Management degree programs.

3 Results and Discussion

The analysis of the professional development stages showed that it starts in high school when students develop their basic information and communication competencies. This earliest stage is of primary importance; therefore, it is necessary to study the motivation of high school students behind the choice of their future career.

The recent publications emphasize the fact that high school students have a general understanding of different professions and choose the courses to study so as to take and pass unified state exams at the end of high school [15, 16]. These exams influence the choice of the degree programs at college or university. As a rule, high schools in our country differentiate their curricula in accordance with the preferences of the students. Thus, there are high schools which focus on STEM disciplines, while other high schools which focus on humanities or economics and mathematics.

Degrees in economics and management are in the top 5 choices of high school students in our country due to the high occupational prestige of the profession and high salaries in this field. Therefore, high school students choose unified state exams in social studies and mathematics required for entering the colleges or universities for the degree programs in economics and management.

Unfortunately, very few of these high school students do understand the real professional life practices of financial managers and can assess their own circumstances to master this profession. As a rule, their professional choice is random, they follow the general trends and their peers.

Multiple sociological surveys show that over 50% of school graduates do not think about their future professions and careers. Moreover, they consider it easier to take exams in social studies and mathematics than in physics, chemistry or biology for engineering programs [17, 18], and of all the university degree programs at their choice with these unified state exams, financial management, innovation management, or economics appear most attractive [19].

Therefore, it is necessary to help high school students in choosing their future profession by influencing their motivation, introducing basic ideas about different professions to them, including the pros and cons of financial management and additional classes in financial management.

Further research into the motivations of college and university students who study in financial management degree programs showed that very often they are disappointed in their choice and don't plan to make their future careers in this field. The standard solution to this problem takes us back to the high school period when professional motivations develop.

In order to get a better understanding and a clear picture of the career success of the graduates from financial management degree programs we conducted a survey covering a population of 400 professionals at the early stages in their careers who graduated from 10 different universities and colleges, including the ones situated in the city of Kazan, Russia, namely, Kazan National Research Technological University, Kazan Federal University, Kazan National Research Technical University named after A.N. Tupolev, Kazan Innovative University named after V.G. Timiryasov, and Kazan Banking School. The population consisted of 84 respondents (21%) holding Master's degrees, 304 respondents (76%) with Bachelor's degrees and 12 Associate degree holders (3%).

The results of the survey showed that only 236 respondents (59%) continued their careers in financial management after getting a degree in it. All these respondents are satisfied with their jobs which met their career expectations. Out of these 236 respondents, however, only 152 survey participants were fully satisfied with the quality of education they received at the university.

The remaining 164 survey participants (41%) changed their career preferences. They were either disappointed in the education they received (51 participant), or in financial management practice (56 participants), or couldn't find a job (56). All of them changed their professions after completing professional development programs.

Among the university environment factors which influenced the success of their education, the respondents gave the highest value to teaching quality, 192 respondents (48%) ranked its influence from 8 to 10 according to Likert scale. These answers go fully in line with recent discussions at international conferences regarding the importance of teaching skills [20], and the use of active teaching and learning methods [21].

Surprisingly, the second highest priority was given to individual characteristics of peers which was ranked from 8 to 10 by 180 respondents (45%). This fact is testimony to incredible potential of communication between the peers and their influence on each other [22].

The lowest values were given to such factors as university equipment (36%), library (33%) and administration quality (32%). Unfortunately, these figures show that the material and technical base of the universities is poor, and should develop intensively, otherwise the universities will have the lowest chances to compete in the international market and attract the best students from other countries [23], and, moreover, intercultural competencies should be enhanced [24].

In Likert scale type questions regarding the quality of the academic courses taught, the highest values were given to courses in finances ranked from 8 to 10 by 185 survey participants (46%). At the same time, only 148 respondents (37%) ranked the quality of courses in entrepreneurship and communication from 8 to 10, which means that more efficient teaching technologies should be introduced in this field.

The most popular answers of the respondents to open questions were accounts (21%), foreign languages (18%), communication (16%), leadership (15%), and psychology (11%). As we can see, most of these competencies refer to soft skills, which are very important at all stages of professional development [25].

The survey revealed the following factors influencing the professional development of financial managers:

- awareness of personal psychological and physiological characteristics and capabilities;
- conscious professional choice;
- adaptability to university and profession;
- willingness for life-long learning;
- readiness for changes in profession.

Based on these factors, the authors identified the following standards for the content of education for financial managers:

- student-centered approach to teaching management;
- marketing, human relations, entrepreneurship and business skills;
- project-based approach to teaching applied skills through real-world practice;
- close collaboration between the universities and employers.

The results showed that the skills formed in university degree programs influence the professional development of financial managers and improve the competitiveness of the graduates. The survey revealed the basic competences of financial managers, including the innovative competences based on the professional standards and market demand. Moreover, professional motivation plays a very important role at all stages of career in financial management.

4 Conclusion

The paper gives recommendations related to introducing changes into the curricula for training financial managers at different levels of education, including Associate, Bachelor's and Master's degrees programs. These recommendations are based on the results of a survey among the body of 400 students. The results indicate the significance of student-centered and project-based approached to teaching and learning to be introduced into curricula. Above that, the authors express their concern about the practical application of skills obtained in universities to real world problems, therefore constant and efficient collaboration between industry and academia is of paramount importance.

The final goal of education is to train highly skilled professionals who can compete in the international market and contribute to sustainable development of the whole world. Therefore, the universities should adjust their curricula to the demands of business community, financial managers being important actors in it.

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University Ecosystem for Student Startups: A 'Platform of Trust' Perspective

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Abstract. In many universities, a continuum and a variety of startup pre-accelerators, startup accelerators; entrepreneurs, investors, and other support actors, are in place to facilitate entrepreneurship and that student startups emerge. In this paper, we describe how the entrepreneurial ecosystem in and Aalto University works. We describe how Aalto's students explore and develop ideas that exhibit "radical creativity"; how faculty and staff at Aalto nurture a "platform of trust" whereby such ideas are not only allowed but also expected; and how "outside entrepreneurs and investors" from the outside come in to work with the best ideas and startups thus developed. The paper proposes implications for policy and management practice in terms of possible import of this model into entrepreneurial ecosystems in and around other universities and other kinds of contexts, and makes a call for further research.

Keywords: Platform of trust · Radical creativity · Entrepreneurial ecosystem · Platform ecosystem

1 Introduction

In recent decades, student entrepreneurship programs in leading universities have been moving beyond traditional classroom teaching to experiential learning, a proven way to improve students' employment outcomes (see e.g. Simon 1996; Gosen and Washbush 2004). Programs such as Skylab at Danish Technological University (DTU) include university mechanisms to facilitate student entrepreneurship. These mechanisms are on a continuum of involvement from startup pre-accelerators through to startup accelerators; involvement of a variety of entrepreneurs, support actors and investors; changes in the particular nature of the university environment and the external context; and, thus, an emergence of an ecosystem for student startups over time (Wright et al. 2017). In the last 90 years or so, the above kinds of mechanisms and entrepreneurial ecosystems have evolved in and around U.S., U.K. and other European universities.

Students' ideas coming out of the above kinds of programs may be hugely interesting as such but are often immature and less well articulated than those coming from seasoned entrepreneurs (Nolte et al. 2020). To put it differently, to take inspiration from research on economic geography, the students' ideas can be said to exhibit "radical creativity" (Power 2010): naïve and poorly crystallized ideas but involving real or potential seeds of revolutionary innovation, industry disruption, and market transformation

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(Xu and Wang 2019; Venkataramani *et al*. 2014). To take one example of radical creativity tracing to a student startup, Rovio Entertainment broke through with its Angry Birds video game in 2009. What was crucial for the success of Angry Birds and industry, and market transformation that followed from its market introduction, was bringing in an entrepreneur and others from outside the university who expected and drove revolutionary innovation not only nationally in Finland, but globally (Ainamo, Dell'Era and Verganti, *in review*).

In this paper, with the foregoing kind of background, we inquire into student startups. We began our inquiry by asking questions such as: How student startups come into being? How students in such startups interact with each other and with entrepreneurs, investors, and other 'non-students'? Is their interaction more associated with one or another industry disruption, with business breakthroughs in neighboring industries, or with global market transformation? How these processes of evolution and emergence perhaps involve entrepreneurs originally from outside the university? We formulated our research question as: 'How and why the roles of entrepreneurial students and external entrepreneurs coevolve over time in a university's entrepreneurial programs and the entrepreneurial ecosystem in and around the university?

Our framework to approach the above questions is based on the concepts of "platform of trust"[1] (Rose-Anderssen and Allen 2008), "platform ecosystem" (Thomas *et al*. 2020), and "radical creativity"[2] (Power 2010). We inquire in this paper into students' radical creativity in the entrepreneurial ecosystem in and around Aalto University, Finland. Here, we pay special attention to students' Aalto Entrepreneurial Society as a linchpin of social relations and key element.

2 Platform of Trust as Departure Point to Study Student Startups

Platform of trust is a concept tracing to sociology and management (Lewis and Weigert 1985; Etzioni 2019). In sociology, research on trust long focused on emotional and cognitive functions and as a deep assumption underwriting social order (Skyrms 2014). Other concepts and topics of interest similarly legitimate included reciprocal exchange, lying, litigation, and monetary attitudes (Lewis and Weigert 1985; Eiteneyer et al. 2019). Based on these foundations in sociology, a 'platform of trust' refers to how human individuals and social groups, as they interact and share experiences in a given context, learn about each other's potential needs, which, in turn, changes their assumptions, and may eventually create a robust foundation for interaction, exchange, and social order (Rose-Anderssen and Allen 2008).

Of late, the concept of platform of trust has diffused also into relative latecomer fields such as the various intersections of civil engineering, management and entrepreneurship research literatures (Singh and Singh 2013; Thomas *et al*. 2017; Laine

[1] We thank prof. Olli Seppänen of Aalto University for suggesting this framework as our approach to study the phenomenon of student startups in the Aalto entrepreneurial ecosystem.

[2] We thank dean Tuomas Auvinen for the idea of complementing the platform of trust perspective with attention to Aalto students' "radical creativity".

et al. 2017). When participants in civil engineering construction projects have shared understanding, there is mutual loyalty, employees and managers can rely on one another, a sense of ownership by all prevails, there is collaboration, there is flexibility, proactive participation, and there is willingness to work long hours when needed (Singh and Singh 2013).

Management and entrepreneurial research literatures have found why and how any "platform ecosystem" is "an architecturally open system, orchestrating external resources as providers, producers, and customers" (Thomas *et al*. 2014; cf. Thomas and Autio 2020; cf. Valkokari 2015). In this view, there are three general types of "leverage methods" (ibid.) that any platform ecosystem can employ for purposes of having greater outputs from available inputs than otherwise. The first of the three kinds of leverage methods is "production leverage"; that is, capabilities to access and even recombine shared assets, designs and standards (cf. Nolte et al. 2020).

The second kind of leverage is "innovation leverage"; that is, capabilities to facilitate the creation of new goods and services. Finally, the third kind of leverage is "transaction leverage"; that is, capabilities to access and to manipulate market-pricing mechanism so as to reduce costs of transaction, search, access, and/or friction (Thomas *et al*. 2014; cf. Thomas and Autio 2020).

In the framework of this paper, trust is one key point of departure and foundation for a platform ecosystem. In an ecosystem with a platform of trust, it is possible to transparently share and manage information across process stages and organizational boundaries. There is sense of security and safe reliance so as to assure character, ability and strength, and to assume truthfulness and sincerity of actors in the industries or other fields involved.

3 Radical Creativity – A Complementary Approach

In the Silicon Valley, Kleiner Perkins is a private equity firm that acts investors in the Silicon Valley with a quite different position in the overall ecosystem than does Kohlbert, Kravis and Roberts, another such firm of investors. Kleiner Perkins is specialized to work closely with radically creative entrepreneurs, while Kohlberg, Kravis and Roberts focuses on continuous trading or transaction (Foster and Kaplan 2001).

Within the more general level of Thomas and Autio's leverage methods, at the transaction end of investors in a platform ecosystem, an ecosystem of roles at a more specific level of analysis can thus be imagined: an "architecture of create, operate, and trade" (Foster and Kaplan 2001). Just as each individual, group or legal entity in an innovation ecosystem has innovation based on knowledge outside and inside, as well as possibly cross-pollinating between the two (Hacklin et al. 2009; Valkokari 2015), similar outside and inside roles can be identified when it comes to platforms of trust: a platform of trust inside (Singh and Singh 2013), as well as one outside (e.g. Business Finland 2018). Internal and external interdependent platforms of trust in terms of production, innovation and transaction provide advantage within each platform and across more than one platform.

Power (2010) argues that in an ecosystem with requisite variety in roles spanning across various actors and their various leverage methods, it is more likely than otherwise that expectations will emerge that allow and promote radical creativity. What matters is the extent that managers of legal entities such as the various kinds of organizations involved in innovation and entrepreneurship have expectations that allow and promote that employees or other individuals and groups engage in radical creativity. In contrast, other researchers than Power have noted that, should diversity be low, the likelihood is that expectations will be in favor of control rather than creativity so that the result at best will be "incremental creativity" at best (Xu and Wang 2019; Venkataramani *et al.* 2017), or more likely, there will be nothing creative or innovative but only "business as usual" (Kaplan and Foster 2001).

4 Data, Methodology, and Research Team

Our phenomenon of interest and data trace to the entrepreneurial ecosystem that has evolved in and around Aalto University since this university was established a decade ago. Our focus is on student startups that have emerged over time; how their processes of emergence and co-evolution have involved entrepreneurs in many cases originally from outside the university; working towards understanding of how and why interaction of startups and entrepreneurs in a particular context may associate with one or another industry disruption, business breakthrough, global market transformation (see e.g. Ståhle and Ainamo 2012; *Valtioneuvosto* 2016), or two or all of the above.

In our data gathering and description of our focal phenomenon, we have begun to document the entrepreneurial programs at Aalto University as multiple cases at more than one level of analysis. These cases will over time be analyzed and compared. But at this stage of inquiry, in this paper, only our intent to do so is flagged.

Our methodology is ethnological and pragmatist. We study the practices and processes of how student startups and the ecosystem that they enter resembles practices and ceremonies particular to how studies in the field of anthropology have found young boys or men or young girls or women go through before they can enter their 'tribe' as more or less fully fledged members.

The cross-disciplinary research team behind this paper makes us well prepared to deliver. Antti Ainamo is professor of international business at Tallinn University of Technology, as well as adjunct professor at Aalto BIZ and adjunct professor at Aalto ARTS, as well as, earlier, a visiting scholar at Stanford University, also working with e.g. prof. Ray Levitt of the Dept of Civil Engineering there, is how he knows Olli Seppänen at Aalto and e.g. Lauri Koskela at University of Huddersfield, as well as in positions at, for example, Swedish School of Textiles near Gothenburg, Peter the Great ST. Petersburg Polytechnic University, etc. He has published in world-class journals. He has also been a visiting professor at Tongji University School of Architecture and Urban Planning. He has ongoing research work with professors Roberto Verganti and Claudio Dell'Era of Politecnico Milan on Angry Birds.

With a Ph.D. from Aalto civil engineering, Ergo Pikas is currently post-doc, working with professor Olli Seppänen at this same department of civil engineering, as well as with prof. Lauri Koskela at University of Huddersfield.

Kari Mikkelä is director of Urban Mill and has a multitude or projects involving Startup Sauna and other elements in the Aalto entrepreneurial ecosystem. He is also a doctoral student at Aalto SCI Dept of Industrial Engineering and Management. Kari knows the Aalto entrepreneurial ecosystem inside out: the different associations, firms, other organizations, etc., as well as very many of the entrepreneurs involved. A key idea is here to leverage on Kari's experience and data, putting it to new use – that of scientific articles in journals such as *Entrepreneurial Theory* and Practice and *Journal of Technology Transfer* in management.

5 Platform Ecosystem in and Around Aalto University

Student startups in the Aalto entrepreneurial ecosystem have over the years involved not only video games such as Angry Birds (as well as to some extent also Hay Day and Clash of the Clans) (Lehtonen et al. 2019) but also in less obvious industries such as construction start-ups in the field of civil engineering. The latter are representative of rather late blooming in comparison to startups in many other industries and fields, but have expanded not less explosively over the last few years. A lot of start-up money is now poured into startups in the construction industry, too.

According to our seminal findings, the physical campus of Aalto University serves as a space and forum for attracting, pooling, deconstructing, cross-pollinating and recombining shared assets, designs and standards (production leverage). Aalto University has developed an international reputation for innovation and mobilization of students and their ideation and co-creation: Aalto's reputation for these is well recognized all around Europe. The Massachusetts Institute of Technology recognized in 2014 Aalto University as a rising star among universities internationally. By extension and the rules of invisible colleges by which the reputation of a university matters, Aalto is clearly an interesting university not only in terms of startups but how students learn by doing about entrepreneurship. Students and researchers at Aalto learn an entrepreneurial mindset, for purposes of corporate entrepreneurship or social entrepreneurship, should they ever need to do anything entrepreneurial, even if they never even try to start up a new venture. Like primordial hunters, the students are "cool hunters" in chase of "where is the beef?".

Aalto University's strong and growing reputation has been a platform for its entrepreneurship programs in and around its campus. In particular, the role of Aalto Entrepreneurial Society (AaltoES), the student body that is responsible for organizing and staffing the world-famous annual Slush event, has been pivotal. AaltoES has been related not so much to the student startups outside itself as such or to the University itself, but to Startup Sauna, to Design Factory, to Urban Mill, to Maria1.0 and to other units for entrepreneurial startups at the boundary or even outside Aalto University. The communities and organizations at the boundary of outside Aalto are concrete proof of "innovation leverage" by which student startups are crystallized and their creation of new goods and services is provided with momentum by professors, other researchers and lecturer, as well as startup-unit managers, as well as by external funders in and around in the Helsinki metropolitan area innovation policy makers (cf. e.g. Business Finland 2018; cf. Valtioneuvosto 2016). Like primordial gatherers, the professors and other innovation-policy implementors are caretakers of students' ideas, "precious babies" that otherwise might not survive from one semester to the next, when students come and go, go on skiing trips, party and experience rapid turnover in their relationships in business and social life.

The third kind of leverage in the Aalto platform of trust ecosystem is “transaction leverage”. The entrepreneurs at the boundary and/or outside the university manipulate market pricing mechanism, access ways how to reduce friction such as transaction and search costs. To put it concretely, external entrepreneurs ‘buy’ student startups cheap from the university and sell them ‘dear’ to investors more distant to the Aalto platform of trust ecosystem than are these entrepreneurs. When an entrepreneur identifies something of value in a start he or has mentored purportedly on a *pro bono* basis, he or she will swoop down and snatch that startup, an individual student or an idea like a mighty eagle from the skies, and carry the startup, student or idea outside campus. In this way, the student or students originally in the role of hunter or predator of cool ideas becomes prey for predators higher in the food chain. It here is worth mention that Peter Vesterbacka, the Aalto-non-student founder in Rovio Entertainment, had “Mighty Eagle” in place of Marketing Director in his business card. But the key is that the student who is preyed upon is a also a winner: he may become entrepreneur or investor himself or herself. The difference between entrepreneur and investors here can be said to be is that investors are more socially and culturally distant to the university and to the student startups than are the trusted-advisor entrepreneurs at the boundary of the university and its external ecosystem context.

6 Conclusion

This paper has outlined research to specify within and beyond the case of student startups in the Aalto platform-of-trust ecosystem three kinds of leverage methods: production leverage, innovation leverage, and transaction leverage. Production leverage is represented by the university campus and the university’s students; innovation leverage represented by professor and entrepreneurs at the boundary of the university and its outside, and transaction leverage represented by outside enterepreneurs and investors. These intertwine in the ecosystem. Such an ecosystem requires both radical creativity and a platform of trust. In between, it is expected that “design thinking” is in a key role, including personal and social linkages between human beings and not only e.g. human-computer interaction.

Implications for practice from this paper for civil engineering, entrepreneurship and university-based ecosystems practice include: understand before digitalize; as well as learn to analyze, codify and even to digitalize before you transfer to another industry, location and/or culture for superior returns. Implications for innovation policy and policy research include understanding what may be equivalent roles to e.g. Business Finland in Finland as providers of funding for entrepreneurial ecosystems in other.

A proposition for further research coming out this paper is to study to what extent and why, in the field of higher education, modeling, codification and export of programs for student startups will benefit from unpacking and being understood in terms of their social relations before exported, and from whose perspective. How and why context matters? A more theoretical call for further research is to take relatively good times in and around Helsinki industrial ecology (such as the one in which Aalto

University is embedded) and compare this kind of university-environment dyad with relatively bad times (such as those recently in and around the Detroit industrial ecology in which University of Michigan is embedded) (Huang-Saad *et al*. 2017; wihurinrahasto.fi). When times are bad rather than good, to what extent may a platform of trust be more or less important in producing radically creative ideas and student startups (see Stutz et al., in print)?

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Occupational Qualification Standard for Truck Drivers as a Risk Management Tool in Road Transportation of Dangerous Goods

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Abstract. The problem studied in this paper focuses on shortages of the diverse approach of professional training of truck drivers in Estonia and studies in details what is its' impact on specific knowledge and training with regards to dangerous goods transportation. Previous studies have identified that the heterogeneous training of truck drivers is a significant risk factor in the road transportation of dangerous goods. The research aims to assess the possibilities for managing risks in road transportation of dangerous goods through the occupational qualification standard of a truck driver in Estonia.

The follow-up study presents a qualitative development research strategy based on the concept of general qualifications system and training system of truck drivers in Estonia. The study is based on primary and secondary data, providing qualitative analysis of interviews and meta-analysis of the results of previous studies. The framework of new study modules is created within the current professional training course of truck drivers based on a designed truck driver's profile. The validation is carried out by expert interviews. The benchmarking collates the qualification requirements and vocational training for professional drivers in Europe with risks within dangerous goods transportation chain identifies the qualitative relationship between them.

The outcome introduces additional study modules into existing truck driver vocational education and training with a methodological approach to improve drivers' competences. This will be an input for developing the occupational qualification standard of a truck driver in Estonia shortly.

Keywords: Occupational qualification standard · Truck driver profession · Road transportation of dangerous goods

1 Introduction

The preparation of road transportation of dangerous goods (DG) consists of a series of skills and knowledge required to prepare for the transport of DG as part of work activities undertaken within the transport and logistics industry [1]. With regards to truck drivers, the preparation of road transportation of DG includes checking DG load and documents related, assessing vehicle suitability to transport intended cargo, checking emergency procedures and equipment, evaluating documented route plans, and completing required assessment process. Acknowledging the existence of

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overlapping risks with their possible consequences in a regular transportation chain with regards to same preparation and following procedures during the transportation makes it possible to manage them proactively in advance with regards to the dangerous goods transportation chain (DGTC) [9].

The content of ADR regulations training for truck drivers is regulated by The European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) [14]. Practical training may affect the safety aspects in peculiar transportations, such as the one of DGT by road. The required competencies for the licence to transport DG by road may be achieved through formal training, *i.e*. ADR regulations training for truck drivers, experience in the workplace (transport and logistics sector), or a combination of both aspects named [1].

The problem discussed in this paper is a follow-up to a broad study on human factor-related risks and their impacts in road transportation of DG. It refers to the shortages in professional training of truck drivers in Estonia from the perspective of specific knowledge and competences with regards to dangerous goods transportation (DGT). The undertaken qualitative research based on results of previous research in the particular filed of DGT, the combination of expert interviews and benchmarking methodology aims to tie up the exiting ADR regulations training for truck drivers and professional truck driver course in Estonia by introducing new study modules into existing truck driver professional training with a particular methodological approach to be readily implemented in practice. All this will contribute to proactive risk management with regards to ensured competences and improved knowledge and at the early stage of truck drivers' professional career. Results can be further implemented in developing occupational qualification standard (OQS) for truck drivers in Estonia, which is relevant with regards to interaction and collaboration of specialist competence with the practical labour market.

2 Background and Previous Studies

2.1 Qualification Framework

The 8-level Estonian Qualifications Framework (EstQF) was established in 2008 and today meets the content and requirements of the European Qualification Framework (EQF). The EstQF has eight levels, the first of which is the lowest and the eighth is the highest. The descriptions of the qualification levels are identical with the EQF level descriptions. EstQF is a comprehensive framework (see Fig. 1), consisting of four sub-frameworks for [5]:

- general education qualifications;
- vocational education and training (VET) qualifications;
- higher education qualifications;
- occupational qualifications.

The OQS is an interface between the labour market and the lifelong learning system enhancing the development, assessment and recognition of persons' professional

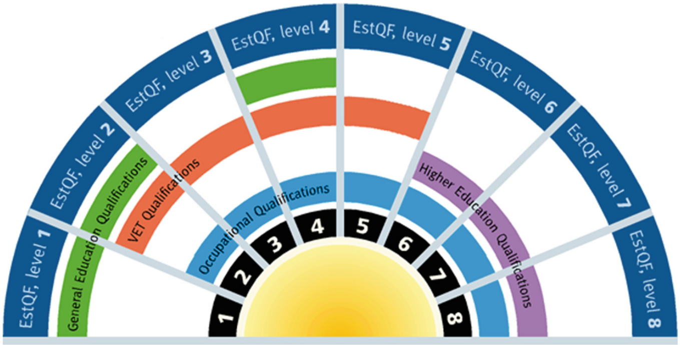

Fig. 1. Estonian qualification framework [5].

competence. The following principles have been taken into account while developing the OQS in Estonia:

- stakeholders of the labour market are involved in all parts of the OQS (employers, employees, the state, trainers) – therefore agreements are based on the co-operation of various stakeholders;
- it follows an integrated qualifications system model;
- the central concept of the OQS is competence, that means the system is based on competence both conceptually and in reality;
- OQS is built and operational as a quality system [5].

A general OSKA (Future Labour and Skills) report on changes in labour requirements, labour market developments and the dominant trends in the field of logistics in Estonia is a source to emphasise the necessity of trained personnel as well as the primary basis for identifying mandatory and optional competencies of the truck driver profession.

2.2 Vocational Education and Training for Drivers

Directive 2003/59/EC lays down requirements for the initial driving qualification and periodic in-service training of professional drivers holding a C or D driving category licence. It requires drivers to prove their initial qualification by taking either training and theory test, or theory and practical test, without any compulsory training beforehand [7]. Then bus and lorry drivers European Union (EU) wide are required to update and refresh their professional skills by undergoing periodic in-service training every five years. Training and educating drivers is a priority among road safety policies. Well trained drivers are safer drivers [16].

In Estonia, two legal acts regulate the work and competences of a truck driver. Firstly, the Road Transport Act lays down the bases for the organization of national and international road transport, including the professional training of drivers, and the training and qualification requirements for the leading transport manager. It also establishes training and qualification requirements for the leading transport manager

[4]. Requirements for the knowledge and skills of train drivers and the content of their general training, requirements for the knowledge and skills of train drivers in order to obtain a certificate, and the rules for the examination for train drivers is the second source document in Estonia with regards to drivers professional training regulates the professional skills and training requirements of the so-called professional driver (incl. truck, bus and taxi driver). Besides, it establishes training and qualification requirements for car, public transport and truck drivers [13].

In Estonia there are both vocational schools and private training companies, providing vocational training for truck drivers. In order to complete the professional training of a driver, a person must have a valid driving license for the category corresponding to the training or he/she must complete professional training combined with the acquisition of a driving license following the Road Transport Act [6]. Regularly the vocational training and its volume are divided as follows: at least 280 h, of which at least 20 h are driving lessons. Vocational training may also be taken in the form of combined training. Within this training the driver acquires the right to drive a vehicle in category C or C1 (truck/lorry), a combination of vehicles in category CE) or C1E (truck/lorry-trailer), a bus in category D or D1 or a combination of vehicles in category DE or D1E (bus-trailer). In this case, the amount of driver training of the driving category is added to the training. The training of a motor vehicle driver of the requested category shall be carried out under the conditions and procedure for the preparation of a motor vehicle driver provided for in the Rod Transport Act.

2.3 Dangerous Goods Transport

When transporting DG, there is always an increased risk to health, safety, property or the environment. Road transport of DG means any movement of DG by the vehicle on a public road or other generally accessible roads, including stops required during the transportation and activities related to this haulage [9]. Legal requirements, according to ADR states that in addition to professional training, the truck drivers shall undergo ADR Regulations Training Courses as in-service training, approved by the competent authority to operate with DG on roads. In practice, it occurs that specific knowledge and training with regards to DG are needed more and more often on a deep level of details in transportation. Based on previous studies, there is a noticeable gap of knowledge and therefore, competency with regards to DG by the novice truck driver. The content of driver's occupational training should include necessary information on DG and their hazard characteristic. Drivers must be able to tell the difference between DG and not dangerous ones. Moreover, considering that, under certain conditions, the transportation of DG in limited quantities (LQ) is allowed without passing the course, in this case, the drivers must also be aware of the risks of DGT [9]. To ensure better safety on the earliest stage in the transportation process, it is crucial to harmonise and standardise training system of truck drivers and link it to the occupational qualification system [9].

Previous studies regarding road transportation of DG are focused on risks related to human factors with regards to DG transport [9], ADR Regulations Training Courses in

Estonia [10], as well as the analysis of theoretical concepts of teaching methods applied in professional training of adults [11], is also used as an input to form harmonised and standardised training system of truck drivers. A general OSKA (Future Labour and Skills) report on changes in labour requirements, labour market developments and the dominant trends in the field of logistics in Estonia is a source to emphasise the necessity of trained personnel as well as the primary basis for identifying mandatory and optional competencies of the truck driver profession.

3 Problem Description

Truck drivers drive trucks for the transport of goods, liquids and materials in national and international transport. They must comply with the conditions laid down by the carrier, the consignor and the consignee, and with the laws and regulations governing the sector [16]. The focus-problem discussed within this paper focuses on shortages of the diverse approach of professional training of truck drivers in Estonia and studies in details what is its' impact on specific knowledge and training with regards to DGT.

The McKinsey Global Institute report finds that the technical potential for automation in transport and warehousing is very high, with transport and warehousing ranking third after accommodation-food services and manufacturing and ahead of agriculture [12]. Frey and Osborne find that work in the field of logistics and transport are most likely automated in the so-called first wave of automation, at the same time as administrative support activities and production work [8]. The model developed by Frey and Osborne focuses on the probability of automating different occupations. Among the professions in the fields of transport, logistics, motor vehicle sales and repair the lowest probability of automation risk among the professions are logistics, purchasing, general and function managers, air traffic controllers, passenger pilots.

One central part and outcome of the occupational qualification system is the system of occupational qualification standards (OQS). OQS is a document which describes occupational activities and provides the competency requirements for occupational qualifications and their levels [5]. The position of a truck driver in road transportation can be characterised by its' diverse nature of work as well as a variable working environment. In addition to specificities of work and personal characteristics of a truck driver, professional activities with regards this profession today are related to three subjects mainly: different parties and people involved into transportation chain, necessary tools and technical equipment, different types of goods within the transportation process.

The work of a truck driver has a creative nature, and aspects that support it are evident in daily work related to non-standard situations and, in particular, problem-solving situations. In case of the driver's professional training and educational system, there is no clear definition of competence requirements and competencies for the given position in Estonia. Until 2007, Estonian occupational qualifications system had a valid professional standard for a truck driver (Truck Driver II), which corresponded upper secondary general education certificate and VET certificate level 4 (upper secondary

VET) according to EstQF (see Fig. 1). Passing the vehicle driving category and vocational training is not sufficient to mitigate the increased risks related to the transport of DG in national and international road transportation. The research aims to assess the possibilities for managing risks in road transportation of DG through the OQS of a truck driver in Estonia.

4 Methodology

4.1 Data Collection

A research design is the set of methods and procedures used in collecting and analysing data in the problem research [3]. It is a framework that has been created to find answers to the research problem. The research strategy of this study is designed based on qualitative development research. It is based on the concept of general qualifications system and training system of truck drivers in Estonia.

Fixed designs usually are theory-driven; otherwise, it is impossible to know in advance which variables need to be controlled and measured. Often, these variables are measured quantitatively. Flexible designs allow for more freedom during the data collection process. One reason for using a flexible research design can be that the variable of interest is not quantitatively measurable, such as culture [15] and human-related aspects, as in the case of this study.

Current research design has a mixed approach. From the perspective of fixed designed elements, the data collection is based on theory and previous studies in road transportation of DG are focused on risks related to human factors with regards to DG transport and ADR Regulations Training Courses in Estonia. The flexibility in the research design is ensured by the number of in-depth interviews that have been performed with relevant parties of the transport sector and VET qualifications. In-depth interviews are a qualitative data collection method that involves direct, one-on-one engagement with individual participants. In-depth interviewing can take place face-to-face or via other communication channels (telephone, Skype, *etc.*). To be effective and to deliver reliable information, the interviewer must be highly skilled to prevent data loss [2]. The following considerations are in favour of the chosen data collection method:

- there is a higher quality of sampling compared to some other data collection methods;
- because in-depth interviews can potentially be so insightful, it is possible to identify highly valuable findings quickly [2].

Within the current study, six interviews were conducted, based on three different structures depending on the interviewee. The main objective of data collecting via interviews was to map the truck driver's profile today and shortly from the perspective of needed competencies, *i.e.* knowledge, skills, attitudes, incl. values (see Table 1).

Table 1. The nature of interviews.

Interviewee	Position	Type of the interview	Duration	Recording method
Carrier company No 1	General manager	Structured	45 min	Notes
Carrier company No 2	General manager	Structured	53 min	Notes
Carrier company No 3	Logistics manager	Structured	41 min	Notes
Vocational school No 1	Programme director	Semi-structured	1 h 4 min	Transcription
Vocational school No 2	Programme director	Semi structured	1 h 17 min	Transcription
Estonian Transport and Road Workers' Trade Union	Chairman	Unstructured	1 h 15 min	Recording

4.2 Data Analysis

Previously defined operational risks within the DG transportation chain on the example of Estonian companies and the analysis of ADR regulations training courses system in Estonia makes it possible to introduce new study modules into existing truck driver professional training with a particular methodological approach to be readily implemented in practice. This also contributes being an input for supporting the necessity for the OQS of a truck driver in Estonia.

Additional interviews were carried out with experts from the leading association in the field of logistics in Estonia. Estonian Supply Chain Association (PROLOG) is a professional in the majority of occupational qualifications in the field of logistics in Estonia. The chosen research design (see Fig. 2) allows solving the research problem and achieve the objective of the research.

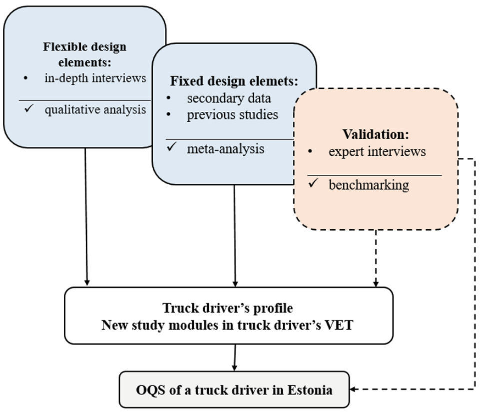

Fig. 2. Research design.

The paper presents a qualitative development research strategy based on previous studies regarding human-related risks within the DGTC and ADR regulations training courses in Estonia. Additional data collection with qualitative analysis and validation of result allows formulating first input into OQS of a truck driver in Estonia. With the implementation of the benchmarking by collating the qualification requirements and vocational training for professional drivers in Europe (ProfDRV) with risks within DGTC precisely, the qualitative relationship between them is identified.

OQS of a truck driver is competence-based and allows to link the gap between risks in practice and needed abilities to perform a specific unit of work or a task together with the knowledge, skills and attitudes required as a professional truck driver. The broader purpose of QOS it to mitigate the increased risks related to the transport of DG in national and international road transportation.

5 Results

Interviews on needed truck driver's competences among different parties within the transportation sector were performed during the period from April 13 – April 30 2020. Carrier companies (n = 3) chosen into the sample have been active in a transportation sector at least eight years, the fleet of companies is more significant than the average in Estonia, and the scope of activity covers different directions in the scope of international road transport. After carrying out comparative analysis based on systemized information from in-depth interviews following findings were done:

- fewer good/competent truck drivers every year; overall lack of personnel in this speciality;
- truck drivers who have acquired a speciality in VET institutions are preferred, the quality of professional trainings in private training companies is assessed as fluctuating;
- technical knowledge and knowledge of foreign languages is expected to become more critical in the near future;
- employers have difficulties finding a skilled workforce to entrust to work;
- the knowledge of legislation is lacking – driving time and rest period, aspects with regards to DGT.

Interviews with VET qualification institutions (n = 2) were conducted at Kehtna and Viljandi Vocational Education Centers. Aims and objectives of both curricula of institutions are similar: acquiring knowledge and skills and attitudes necessary for working as a truck driver both independently and in a team by creating the preconditions for continuing studies and lifelong learning. Following findings from interviews with VET institutions were done:

- the labour demand of truck drivers exceeds the training offer;
- the position of the truck driver remains attractive - people come to study just in case, but in recent years some people want to study to have the profession of a truck driver in practice;

- the proportion of specific knowledge, responsibilities and level of salary of the truck driver is out of place;
- VET qualification institutions are aware of the relative importance of legislative aspects with regards to the profession of a truck driver and focus on legislation and road safety.

Estonian Transport and Road Workers' Trade Union is an association of transport workers. The following aspects emerged from the interview:

- main reasons for joining the association are the wish to get legal aid, resolve labour disputes, respond to claims for damages, get help in traffic assistance, *etc.*;
- only several hundred truck drivers are involved as members of the union within more than 2,000 members all together;
- most significant concerns/disagreements of the members of the union regarding their work are related to traffic accidents, damages/fines, redundancies;
- the more truck drivers there are in the union, the better the union will be able to represent them and thus raise their awareness.

The results of the interviews were input for creating a truck driver's profile (see Fig. 3).

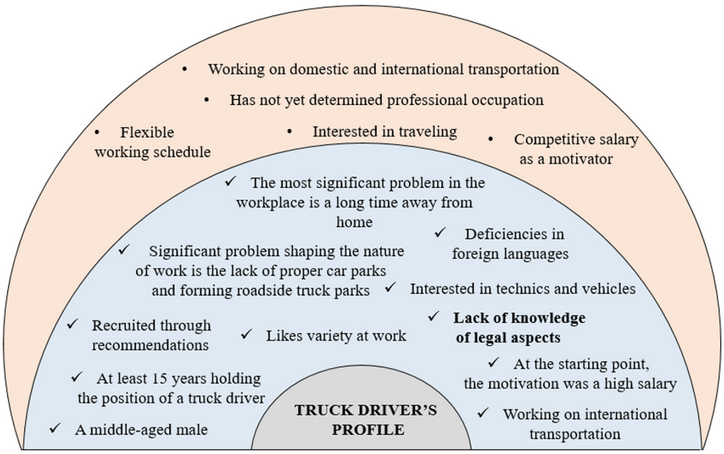

Fig. 3. Truck driver's profile.

The truck driver's profile summarises the aspects that mainly characterize the truck driver today (the internal section of a figure) and soon (up to 5 years, the external section of a figure). Additional features will supplement the profile in addition to existing aspects today. All these aspects can be equated with specific competencies needed at daily work in transportation as a truck driver (*i.e.* knowledge, skills, attitudes, incl. values). According to the created profile, lack of knowledge of legal matters is a relevant point to deficiencies with regards to DGT.

The following insight into existing operational risks within DGTC among different parties allows linking specific human-related risks and features of a truck driver according to the profile. Besides the methodical approach studied in previous studies [9–11] on the example of Estonia will be taken as a basis to introduce new study modules into existing truck driver vocational training with particular teaching methods to be implemented in practice to develop profession-specific competencies (see Table 2).

Table 2. Competency-based risk management.

Operational risk (n = 15)	Carriers' risk level	Methodical approach related to DGT	Driver's competence
Inaccurate customer communication	Tolerable	–	**Customer service** **Freight transport planning and organization** **Quality management** **Safety and security management**
Incomplete transport documentation	Tolerable	Practical tasks	
Improper transport documentation	Tolerable	Practical tasks	
Missing transport permits and licenses	Acceptable	–	
Not safe load securing	Tolerable	Group works based on watching videos	
Inadequate packaging	Tolerable	–	
Insecure loading/unloading	Tolerable	Group works based on watching videos	
Wrong classification of DG	Acceptable	–	
Inadequate load securing	Acceptable	Practical tasks	
The use of incorrect load restraints	Acceptable	Practical tasks	
Driver's caused error/accident	Acceptable	Peer-learning	
Improper packing material	Acceptable	–	
Wrong/missing marks and labels on the package	Acceptable	–	
Wrong route planning/choice	Acceptable	Peer-learning	
Wrong/missing vehicle placards	Acceptable	Practical tasks	

Considering that mainly half of the carriers' operational risks are classified as tolerable risks with significant consequences and with a slight possibility to take place [9], it is therefore proposed to include topics related to tolerable risk into the VET beforehand. The other topics should be in focus with regards to improving ADR regulations training for truck drivers mainly. The validation of presented results with representatives of PROLOG and executing primary benchmarking with results of ProfDRV remarks on qualification requirements and vocational training for professional drivers in Europe [17]. Following supportive aspects can be pointed out with regards to harmonising and standardising training system of truck drivers and link it to the VET and occupational qualification system:

- the qualification of professional truck drivers is considered to be a vital factor regarding safety on all levels with high relevance for all EU member states;
- harmonising educational policies within member states of the EU;
- updating the specific content and methodical approach of VET according to the local market and the professional characteristics.

6 Conclusion

The paper is focused on a problem on shortages in professional training of truck drivers in Estonia from the perspective of specific knowledge and competences with regards to DGT. Outcomes of the study research are presented in two phases within this paper. In the first phase of outcomes, the truck drivers' profile is formed. The second phase of results is mostly meta-analysis based and is focused on improving existing VET of truck drivers in Estonia with new study modules with a suitable methodological approach. Improved programme in practice aims to manage general and specific (*i.e.* related to DGT) risks within the transportation chain.

In the situation of a global pandemic of COVID-19 in the field of transportation and logistics has been full of rapid and unexpected changes. Moreover, in crisis, typically less attractive professions, such as truck driver occupation, are becoming crucial. With regards to international truck driver profession, labour market expects even fewer mistakes and even more homogeneity in professionalism and resulting high quality of provided service. OSKA report in the field of logistics is an essential input in identifying the real needs of the labour market. The sector needs for truck drivers with skills and knowledge that are needed for starting working independently right after finishing a professional training course of truck drivers. These truck drivers have to be ready to transport DG beginning from the very first working day. One possible approach for managing risks is harmonised and standardised training system of truck drivers on a level of VET with a clear relation to specific competencies of OQS. Further research related to this issue is focused on developing a comprehensive quality standard for truck driver profession in Estonia.

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Use of AI for Improving Employee Motivation and Satisfaction

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Abstract. Along with the introduction and use of new and modern technologies, the work environment has changed dramatically. Many companies are using technology-based communication tools for their internal communication. Engineers have to be educated about these changes and affected factors to develop better communication systems. Technology users are facing problems arising from the lack of non-verbal cues in communication. Organizations need to get technological solutions to improve technology-based communication efficiency and have more motivated and satisfied employees. The use of technology-based communication tools for work is relatively new and possesses several challenges. Recent changes caused by the pandemic in 2020 revealed some of these challenges and how vital communication technologies are for our current society. The problem of motivating employees while using technology-based communication tools has not yet fully addressed addressed. Engineering professionals and students need clear guidance and structure in order to understand the factors involved and possible problems as well as the impact on people using it. The goal of this research is to investigate the factors that are important within technology-based communication and to develop a simulation model for engineering students and communication system developers. Using the developed simulation model technologies can be created involving necessary constructs and tested for necessary improvements.

Keywords: Technology-based communication · Work motivation · System modeling · Automated estimation

1 Introduction

Managers are facing new issues and problems because of modern communication formats, and different solutions have to be found [1].

There is extensive research on how to manage teams in a work setting where team members have frequent face-to-face meetings. Using technology-based communication for work is a relatively new concept, and possesses several challenges including the motivation of employees when technology-based communication tools are utilized [5]. Despite the vast amount of research in social sciences as well as advancements in emerging technologies, rarely have these two fields been merged [2].

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Barrier (2002) states that information systems must be managed and instead of blindly accepting and introducing components into information systems, system developers should study the effectiveness, feasibility, and efficiency of the individual components of their information systems [3]. Technology developers and engineering students can benefit from using social science research in the development of their technologies. If new technologies include this knowledge, they will be more effective not only as technologies but also more user-friendly. Studies have highlighted engineering students' lack of understanding of human nature and lack of emotional intelligence [5], but using these research results, they will be able to improve their skills in this area.

It has been predicted that companies will compete for both technology and human resources in the future [4]. This research aims to investigate the factors that are important within technology-based communication and to develop a simulation model of employee motivation and satisfaction for predicting the possibility of an employee leaving the company.

The presented model is built upon previous studies and extends them with a simulated model on motivation, culture, employee satisfaction and turnover intent. The study improves upon previous models by using Artificial Intelligence (AI) to identify hidden constructs and relationships.

The developed model can guide other studies on using sophisticated data analysis and development of new technologies to managerial communication and decision-making. The model could be useful for managers while identifying the relevant factors for improving their work communication. This computer-based method has the ability to eliminate inherent workplace bias problems. By understanding this model and implementing behavioural science knowledge in the development of IT systems, engineers can improve their communication technologies.

2 Technology-Based Communication

The introduction of new technologies has many advantages and benefits to organizations. Communication can happen in four different settings according to time and place [6, 7]: Same-time and same-place communication happens in the form of face-to-face meetings. Same-time and different-place meetings can be video, audio or text. Different-time and same-place is a meeting when a meeting is recorded in a storage place and can be used for employees with different time shifts. Different-time and different-place meeting is a form where participants share the same virtual space and web. Each of these settings can be applied depending on the situation, purpose, available resources, and context of the transmitted message. It is critical for management to decide which type of media is most appropriate to utilize in a given situation. Within Media Richness Theory, different means of technology are arranged from leaner medium channels to richer medium channels [8]. Leaner medium channels such as bulk mails, posters, written documents are considered less effective. Phone calls and video calls are considered more effective channels, but the most effective way of communications are face-to-face meetings and events since they provide high bandwidth for the communication. According to this theory, the choice of communication channels should be according to the specific situation. Leaner medium channels can be used for general announcements, but severe and problem-solving issues require richer medium channels [8].

Pauga and Cakula (2019) found that e-mails and phone calls are the most popular means of work communication, even though various new technologies are available [5]. However, in another study, video-conferencing was not found to be an equal substitute for face-to-face meetings [9]. Video-conferencing brings the image together with the name of the participant, but still misses necessary non-verbal cues for effective communication. A considerable amount of communication is non-verbal: kinesics (i.e., facial expressions, gestures, body movement); proxemics (i.e., perception and use of space); chronemics (i.e., perception and use of time) [10]. Missing facial expressions and non-verbal cues cause lack of interpersonal relations, social rapport and lead to less satisfied members [11]. It becomes harder to know if the information was understood fully or correctly, and can be challenging to establish and maintain mutual knowledge [12]. These problems are more complex across different cultures and can lead to false conclusions and assumptions about a person's character [7, 13].

2.1 Communication Technologies and Culture

The impact of communication can vary across different cultures [14]. There is often a gap in the developer's knowledge of culture-dependent user requirements for products that are developed for different cultural markets [15]. Cultural awareness should be one of the key features for new and user-friendly communication tools [16].

In spite of the general view about communication problems arising from differences in linguistic codes, Hall (1976) argues that the real issue comes from the context, where various proportions of meaning can behold [17]. Spoken language is an abstraction of thoughts and written communication is an abstraction of spoken language. People choose some parts of information for transmission and subconsciously ignore other parts [17]. Consequently, the actual event happening is much more complex and more vibrant than the abstraction of itself within the spoken language and written language.

According to Hall (1976), any transaction can be characterized as high, low or middle context [17]. While high context (HC) communication is identified with more context and little or no information, low context (LC) communication contains much information with little or no hidden context. Within technology-based communication, the most complicated issue is transmitting the desired message in HC communication. As most of the meaning is not transmitted in words, it can lead to misunderstandings. Programming can resolve this issue by providing sufficient HC communication [17]. Controversy in LC communication can be very brief, may not have all information explained in sufficient detail, and may lack emotion and personal relationships.

Hofstede (1983) pointed out four basic dimensions – power distance, uncertainty avoidance, individualism versus collectivism, and masculinity versus femininity [18]. Hofstede defines culture as the collective mental programming of people in an environment. It is not a characteristic of individuals, but rather result of conditioning by education and life experience group [19]. Changing one's culture is usually very challenging, and management theories often are generalized. In this study, these four dimensions were included in the simulated model of technology-based communication since different collective mental programming can result in differences in communication. Within the work-related context, these dimensions determine different ways of structuring organizations, different motivations of people within organizations, and different issues people and organizations face within society. For many organization theorists research data and life experience were collected within their own society. Organization theories are, therefore, culturally bounded [18].

2.2 Motivation Through Technologies

In new modernized work setting motivation will be the main competitive advantage [20]. Motivation can be briefly defined as a person's internal psychological forces, which moves them to work [21]. Herzberg (2003) found out that reducing time spent at work, spiraling wages, fringe benefits, human relation training, sensitivity training, two-way communication, job participation and employee counselling are just myths of motivation [22]. These approaches can be practical, but they are not long-term motivators. The concept of motivation is much more complicated than most people would believe [22]. Different studies show that employees craved to be singled out and made to feel important [23–25]. People have a natural striving for self-realization. The most persistent incentive is self-respect and the respect of others. Employees need to feel that they are a part of a worthwhile project, have responsibilities and that they are rewarded for outstanding performance [23–25]. These factors are especially important for virtual teams because Herzberg's mentioned myths of motivation will not be enough to motivate them [22–24, 26].

Herzberg's motivation two-factor theory identifies the actual factors that lead to satisfaction [24]. He divided different important constructs into Hygiene and Motivator factors. Hygiene (extrinsic) factors do not motivate employees to be extra satisfied, but rather ensure that they are not dissatisfied. Hygiene factors include supervision, interpersonal relations, physical and working conditions, salary, company policies and administrative practices, benefits, and job security.

Motivators (intrinsic) factors can be listed as achievement, recognition for achievement, the work itself, responsibility, and growth or advancement [21, 22, 24]. These are the factors that reward the needs of the individual to reach his aspirations and are the ones that bring real job satisfaction. Most technologies do not include motivational factors. This knowledge is rarely presented to engineering students, and for that reason, many technology developers do not include it in their developed systems.

Motivated and satisfied employees are especially crucial for keeping employees in an organization because dissatisfaction leads to higher turnover intent (employees leaving their job) [5, 25]. Employee turnover intent rate can be a result of job satisfaction measure [28–30]. It is very time-consuming and expensive for a company to have a high turnover of employees.

2.3 Virtual Leadership

Appropriate leadership is an essential factor for improving relationships within companies that use technology for their communication [9]. It is harder to overcome the challenges of structuring team processes and to provide necessary task support [31].

Employees may have difficulties feeling like a part of the team, and more active leadership is required [7].

The leader-member theory (LMX) explains the relationships between employee and leader [32]. Employees can feel either as in-group members or as out-group members. Leaders consider in-group members superior to other employees, better at work, reliable and loyal. Employees who are out-group members have difficulties communicating with the leader, and it results in lower performance and satisfaction. They get fewer advantages, are less trusted, receive less attention, support and supervision [32–34]. In the virtual workplace, communication strategy has to be implemented in a way that all employees would feel like a part of the same team and would be willing to deliver the best performance. It can affect employee turnover intent, overall organizational citizenship behaviour, organizational commitment, general job satisfaction, and result in lower job performance [27].

It was discovered that technology-based communication could be as effective as face-to-face communication with appropriate leadership and communication strategy [5]. Technology developers should support leaders by developing communication systems that include the understanding of these arising communication barriers within virtual teams.

3 The Proposed Model

Previously, models and calculations, presentation pads, technical designs and word-processing were all performed by individuals. Technology has drastically reduced the cost of these activities. In other words, the ability to use pertinent information based on the estimation of unknown data could help the company to preserve employees or increase their performance.

The principle of technology-based communication consists of estimating actions using the data available, then deriving results and integrating them into those data. This is an efficient modelling cycle, for example, to know the degree of satisfaction of employees in a company. Generally, these tasks were performed by providing surveys. In this paper, we propose a computer-based model to estimate satisfaction based on parameters such as motivational factors and cultural context. The simulation is proceeded using the software "Anylogic". This tool aims to create variated structures that could be considered as a model in many areas.

Data used for the development of the simulation model was gathered from an online survey with 102 respondents. The survey included 93 questions using a 10-point Likert scale, covering topics of work motivation and the use of technology at the workplace. Respondents were from 26 different nationalities and a wide age group (19–63 years old).

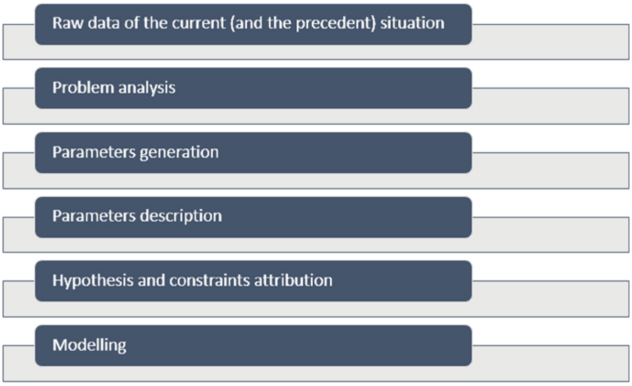

Fig. 1. Processing steps of our modelisation.

The proposed model is based on the following six main steps (Fig. 1):

1. **Raw data** of the current (and the precedent) situation: data concerning all employees work in the company (even the retired and fired employees), as well as motivational factors, individualism, hygiene factors, etc.
2. **Problem analysis:** a global analysis of data and its parameters;
3. **Parameters generation:** selection and generation of relevant data that could help the system to decide;
4. **Parameters description:** description of the selected data with statistical comparison;
5. **Hypothesis and constraints attribution:** definition of the constraints that have a high potential to change the employees' behaviour;
6. **Modelling** building of the proposed model itself.

4 Experimental Results

AnyLogic is a simulation tool developed by The AnyLogic Company. AnyLogic has a graphical modeling language and also facilitates the extension of the simulation model with Java code. The PLE edition of AnyLogic is available for free for educational use.

AnyLogic processes the graphical modeling language, and allows the user to perform simulation models with Java code. The nature of using Java in AnyLogic is related to extending custom templates via Java encoding, as well as creating Java applets, which can be opened with any standard browser. These applets make Any-Logic templates very easy to share or place on websites. In addition to applets, the professional version allows the creation of Java independent applications that can be distributed to users. These Java applications can serve as a basis for decision support.

4.1 Technical Modeling

The system to be simulated consists of a source (input), a station (server + queue) and an output. Figure 2 illustrates the previous elements in the simulation.

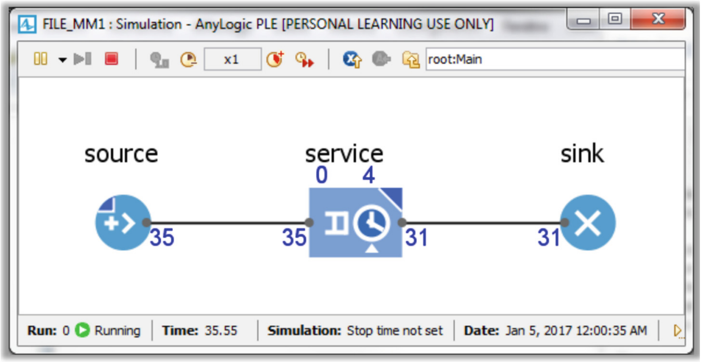

Fig. 2. The main modelling elements.

Three elements must be used:

- **Source:** For the source, it must be specified that the arrivals are defined by an inter-arrival duration and that the inter-arrival duration is 1.
- **Service:** At the service level, it is recommended to specify a queue length waiting and a processing time (Delay Time).
- **Sink:** Contains the output: the desired results that we would obtain.

This project will use the notion of agent. An agent can correspond to a "classical" flow element as we have it in a discrete event simulation model. Each agent is considered as an employee in the company.

4.2 The Proposed Model

The proposed model is presented in Fig. 3. In the proposed model we distinguish three main elements:

- State;
- Global variable: initial or random values based on the database;
- Flow.

Figure 3 represents the process of employee's activities in order to calculate the satisfaction rate. This factor is important for employee behaviour estimation if they are going to leave the company or they have all conditions to stay longer. In our case, we used a dataset that contains a list of parameters that we extracted from the processing of certain fact (such as communication with other employees) or information concerning each employee (such as nature of work, culture, etc.).

The parameters (or features of interest) are as follows:

- Cultural factors – HC or LC cultures and culture dimensions;
- Motivational factors: intrinsic and extrinsic factors;
- Communication: media richness and frequency of face to face communication;
- Work description: nature of work, environment and conditions.

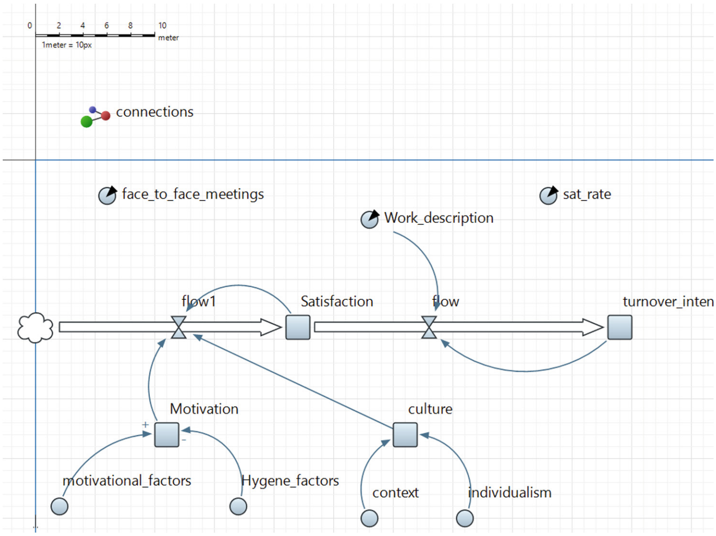

Fig. 3. The proposed model.

Each factor is represented by an arithmetic equation based on specific information given from the data. Based on the history of employees in the company (extracted from questionnaire), the proposed system generates structured random combinations of factors in order to estimate the behaviour of those new data entries. The probability before and after adding specific parameters is then calculated by computing the average rate of all data related to a specific factor. Figure 4 represents the obtained probabilities of the generated data entry.

Technically, the model is composed in part, data, satisfaction and intent.

Data → satisfaction → intent

To calculate the satisfaction, we add the rates of motivational, cultural, and communicational factors, then we compute the probability of satisfaction itself. This probability will be modified another time by the addition of work description factors.

4.3 Obtained Estimation

The satisfaction and turnover intent rates from the data set are illustrated in Fig. 4. The average of motivational and cultural factors is shown on the left. From the graph, it can be observed that the increase of motivational factors and teamwork predicts a high estimate of employee's satisfaction (0, 30). In this case, we reach a probability between 0.6 to 0.84.

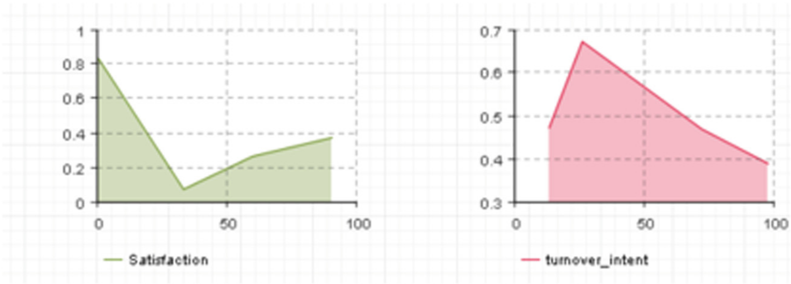

Fig. 4. The obtained estimates by the proposed model. Once the satisfaction is increased (on the left - green), the probability of abundance is rather decreased (on the right - red).

On the other hand, when the motivational factors are less or empty and do work individually (30–60) the satisfaction rate decreases. The probability obtained in this case is approximately between 0.1 and 0.3. Another important observation, when the employees get minor motivational benefits and work in a team, the probability of satisfaction is increasing slowly, but not enough to reach a high level of satisfaction. The obtained probability is approximately 0.4.

In parallel, the figure on the right (of Fig. 4), represents the probability of the employees to quit the job due to job satisfaction and conditions. The major conclusion that we have drawn using the graph is the probability of resignation is increasing once the satisfaction is less than 0.6.

The model is providing the rate of satisfaction, and estimation of the resignation rate quantitatively. Organisations can evaluate which factor should be corrected among the cited factors, and this in turn could serve as guidance to system developers for understanding the weight of each element when testing their new systems.

5 Conclusions

Development of technologies and new ways of communication has given as many challenges as benefits. It connects people all over the world, gives more flexibility and increases speed of work, though the messages people convey may lose meaning and context. For face-to-face communication a considerable amount of communication is non-verbal which is difficult to transmit through technology-based means. It is especially difficult within multicultural contexts. Many different aspects must be considered, in this research Hall's theory of Low-context and High-context cultures and Hofstede's theory of four culture dimensions were used as the theoretical foundation of the study.

Motivation is an important factor affecting employee satisfaction. However, motivating employees using technology-based communication is a challenge. Herzberg's two-factor theory explains which factors are dissatisfaction avoidance and which ones are actual motivators and helps to have satisfied employees.

Developers need guidance for new system development, and technological solutions for companies have to be offered. The presented simulation model demonstrates essential factors to be considered in technology-based communication and how these factors affect each other, leading to employee satisfaction and their decision to stay with or leave the company. By understanding this model and implementing behavioural science knowledge in the development of IT systems, engineers can improve their technologies' effectiveness and adapt to new and modernised communication technologies.

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University-Business Collaboration in Engineering: A Bibliographic Coupling Analysis

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Abstract. The scientific literature shows different cases that highlight the importance of university-industry cooperation for training in the area of engineering. Specifically, in engineering, the university's relationship with industry allows for greater ownership of established competencies in the training process, making graduates more attractive to the industry and encourages collective learning. In that sense, we conducted a bibliometric study related to university-business cooperation, specifically in the area of engineering. We performed a bibliographic coupling analysis to identify the most relevant publications in this field of study. We identified five big areas of research about the university-industry relationship in engineering: 1) Individual and organizational determinants of university-industry cooperation. 2) Impacts of university-business cooperation on industrial activity. 3) The relation between scientific productivity and collaboration with the industry. 4) The entrepreneurial university (business intentions of researchers). 5) Motivations of universities to cooperate with the industry. We suggest future lines of research based on the results of our study.

Keywords: University-industry · Collaboration · Engineering

1 Introduction

In recent years, literature has delved into the analysis of the forms of interaction between the university-industry [1–4]. Indeed, this field of knowledge is considered of vital importance for the competitiveness of world economies [4] and for the development of national innovation systems [5]. In fact, higher education broadly recognizes the importance of university-enterprise interactions [6–8] for the effective development of competencies in students and the improvement of the educational quality of academic programs.

University-industry cooperation involves the interaction of different organizational structures and factors, depending on the nature and objectives of stakeholders [9]. In this regard, previous studies [3, 5, 10] have analysed the barriers and motivations of this kind of cooperation. Universities cooperate with companies motivated by access to new knowledge, complementary experience, or funding for project development, as well as to improve student training through practical exercises, and to exploit research

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outcomes [10]. For its part, the motivations of the industry correspond to access to qualified human talent, the commercialization of technologies results of research, the development of products more quickly [10].

These objectives are developed through different mechanisms such as regular visits of academic staff to industry, the inclusion of industrial internships in curricula or the holding of seminars or joint meetings [5]. In this way, company university cooperation allows accelerating innovation processes, share resources and risks in projects and generate competitive advantages by accessing new ideas and sources of knowledge [3].

However, previous studies identify the following obstacles to University-Business interaction: lack of project funding, communication difficulties, and understanding of the benefits of cooperation [3, 5, 10], difference in the priorities of academic and business organizations, lack of time to establish collaborative projects [3, 5], lack of trust and mutual engagement among stakeholders, difficulty developing intellectual property agreements and other types of contracts, deficiencies in absorption capacity [3, 10].

University industry cooperation is an important challenge, due to the difference in the objectives of each institution, on the one hand, the university is oriented to spread knowledge, while the industry aims to identify knowledge applied to its problems [11]. However, establishing a collaboration between the university and industry is vital to the success of university training in engineering programs [7, 8]. The literature shows different cases that highlight the importance of university-industry cooperation for training in the area of engineering [2, 7, 8, 12–21]. Specifically in engineering, the university's relationship with industry allows for greater ownership of established competencies in the training process, making graduates more attractive to the industry [12], and encourages collective learning [7]. Considering the above, we conducted a bibliometric study related to university-company cooperation, specifically in the area of engineering.

2 Methodology

2.1 Studies Identification

To identify the scientific publications, we performed a search in the electronic database Web of Science using the following terms combination:

> ("university business" OR "university-business" OR "university-industry" OR "industry-science" OR "science to business" OR "science 2 business" OR "industry collaboration") AND ("alliance" OR "collaboration" OR "cooperation" OR "interaction" OR "link" OR "partnership" OR "relationship" OR "relation" OR "transfer") AND ("engineering" OR "engineer")

The search was performed on the title, summary, and keywords of the posts. The initial search yielded a total of 127 results. We included articles published until 2019 and in English. Regarding the type of document, we only include scientific articles; editorials, conference articles, notes, and other material were excluded. Thus, after excluding publications that did not meet the requirements of year of publication, language and document type, we retained 123 publications.

2.2 Analysis of the Studies

Bibliometrics is commonly adopted to analyse research publications from a quantitative perspective. Bibliometrics allows to identify the most influential publications as well as the most important researchers, using metric citation counts. With the citation count is possible to know the influence and visibility of any scientific publication [22]. First, we perform a descriptive analysis of the evolution of publications on the topic, showing the number of documents published per year, as well as the journals that lead the publication on the subject.

Bibliometric analysis "is often combined with science mapping techniques to visualize the intellectual structure of a particular research field" (Leung, Sun, & Bai [23], p. 36). According to [22], the "network analysis is the graphical analysis developed in the bibliometric study context to understand the relation (intensity and centrality) between keywords, authors, and references" (p. 99). Thus, secondly, we performed a bibliographic coupling analysis. Two papers are bibliographic coupling when they have cited the same article (an article c) in their reference list. The advantage of using bibliographic coupling is that allows to include recent published papers, compared to co-citation or direct citation that only cover the most cited papers [24]. This type of analysis was conducted with VOSviewer, a free software for bibliographic mapping.

3 Results

3.1 Descriptive Analysis

Regarding the evolution of the scientific publications, we can note that the first article about the relationship between university and industry in engineering, was published in 1997. From that date, at least two periods can be identified: in the first, from 1997–2010, an average of 2.4 articles per year were published. In the second, from 2011 to 2019, an average of 9.8 articles were published per year (Fig. 1).

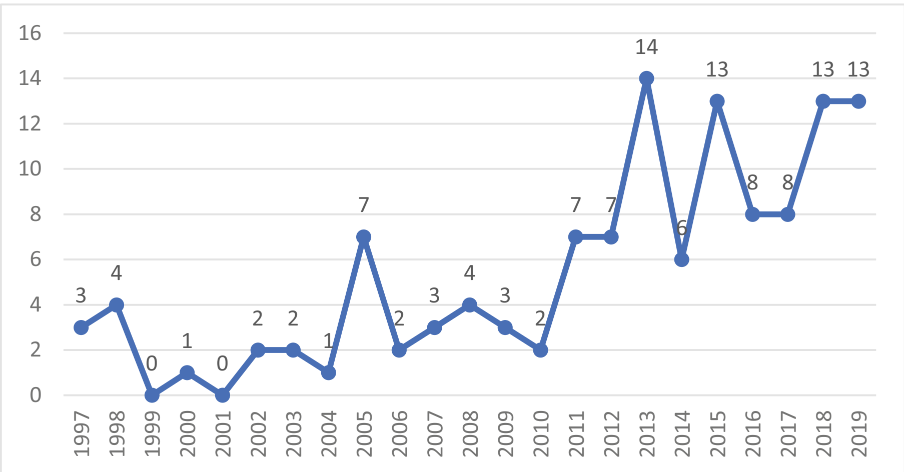

Fig. 1. Evolution of the scientific publications per year.

The journals that concentrate the greatest number of publications are the International Journal of Engineering Education, Research Policy, and Scientometrics (Table 1). In the first one, only manuscripts that have a focus on engineering education are considered for publication; Research Policy publishes articles that examine empirically and theoretically the interaction between innovation, technology or research, while Scientometrics is concerned with the quantitative features and characteristics of science and scientific research.

Table 1. Leading journals in the university-business research

Journal	Nº articles	%
International Journal of Engineering Education	21	17.07%
Research Policy	9	7.3%
Scientometrics	9	7.3%
Journal of Technology Transfer	8	6.5%
Computer Applications in Engineering Education	6	4.8%
Technovation	5	4.06%
Higher Education	3	2.43%

3.2 Bibliographic Coupling Analysis

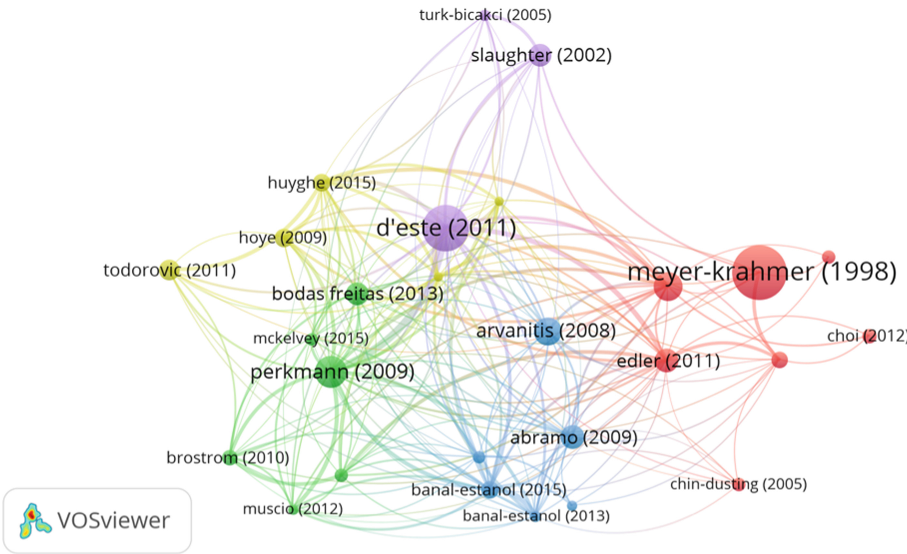

Fig. 2. Bibliographic coupling analysis.

Cluster 1: Individual and Organizational Determinants of University-Industry Cooperation

The first cluster groups the studies related to the determinants of the University-Industry cooperation process (Fig. 2). In that sense, the article [25] concludes that the participation of researchers in collaborative processes with industry can be fostered by their academic productivity, participation in a network with different industry or government actors, and the assignment of budget for knowledge transfer activities [25]. Moreover, the possibility of acquiring research funds is a factor that motivates researchers to collaborate with the industry [1]. In contrast, differences in the research cultures of companies and universities, derived from the orientation to short-term results in the industry, is perceived as a barrier to university-industry cooperation processes [1]. However, according to the article [1], from the academy's perspective, the advantages of these cooperation processes are greater than the disadvantages.

The study [26] focuses on the analysis of the frequency and duration of international academic mobility activities as a determining factor of the processes of knowledge and technology transfer. The results highlight that researchers who carry out temporary mobility are more likely to participate in transfer activities for companies, both in the country of mobility and in the one of origin [26]. In addition, consulting, research grants [27] and collaborative research [1, 27] are important mechanisms to transfer knowledge to companies.

On the other hand, the cluster analysis shows that there are variations in the models of interaction between universities and the industry, as well as in the perceptions of the benefits of these interactions [28], likewise, there are differences in the patterns of university-industry interaction depending on the technological fields [1]. In this context, trust, mutual scientific respect and the identification of common objectives between the university and the industry, are fundamental factors to promote an effective collaboration [28]. Furthermore, institutional rules and behaviours are relevant factors for the implementation of educational innovations in engineering and the success of university-industry partnerships [29]. In this respect, the study carried out at the University of Sussex [27] states that schools differ in the way their teachers participate in university-industry collaborations.

From another perspective, [30] analyse the factors that affect the processes of international scientific collaboration of OECD member countries. They found that the context of globalization and information technologies influence the collaborative links among countries while factors related to geographic, linguistic and economic affinities do not have a significant role to explain these collaborations [30].

Cluster 2: Impacts of University-Business Cooperation on Industrial Activity

The studies included in the second cluster analyse the impact of university-business cooperation on the performance of industry activities. Firstly, university-industry collaboration impacts the innovation processes of companies [31–34]. In this respect, the empirical evidence demonstrates that the role of university-industry collaboration has differences in mature versus emerging industries [31]. Mature industries collaborate with universities to expand their knowledge or improve the integration of knowledge and technology, while emerging industries interact with academia to obtain scientific support to develop new products or knowledge [31]. Moreover, there are differences in the role of university-industry collaboration in small and large firms, for example, in the use of knowledge derived from collaborative research [32].

Second, university-industry collaboration impacts companies' research and development (R&D) efforts [35]. The study conducted in UK companies [35] found a positive effect on R&D spending per employee in companies participating in collaborative projects with universities. Furthermore, the research carried out with a group of managers of Swedish engineering companies [33] indicates that geographical proximity to universities contributes to the development and commercialization of R&D projects and favours meaningful learning in companies [33]. The article [34] demonstrates that the proximity of the universities to the industries, promotes the establishment of collaboration agreements. Finally, literature [36] emphasizes the complementarity between solving problems in the industry and scientific research, through mechanisms such as consulting [36].

Cluster 3: Relation Between Scientific Productivity and Collaboration with the Industry

This cluster addresses the impact of university-industry collaboration on academic productivity: scientific publications, patents and the result of collaborative projects. This cluster includes studies developed by academic institutions in Switzerland [37], United Kingdom [38–40] and the United States [41]. A group of studies [38, 39, 42] analyses the effects of collaboration on scientific publication. This cluster also analyses the results of collaborative projects between the university and the industry, in terms of quality and type of project [40] and the university-industry collaboration patterns implemented in the generation of patents [41]. In this respect, the study [41] showed significant differences in the pattern of collaboration depending on the types of patents obtained in the projects [41].

Finally, the article [37] states that academic institutions cooperate with industry to access knowledge of the business sector, obtain financing for projects, strengthen the processes of extension and visibility of the university and contribute to regional development [37]. In the field of engineering, educational and consulting activities are key mechanisms to transfer knowledge with the industry [37].

Cluster 4: The Entrepreneurial University (Business Intentions of Researchers)

This cluster analyses the characteristics of the entrepreneurial university and the profiles of researchers who commercialize innovations in the industry. In this cluster the profile of researchers with capacities for the commercialization of innovations in the engineering faculty of a university in Canada is analysed [43], as well as the influence of organizational culture on the entrepreneurial intentions of a group of scientists in Sweden and Germany [44] and gender differences in participation in university-industry collaboration activities in UK scientists [45]. Additionally, the study [46] proposes a scale to measure the entrepreneurial orientation of universities. In this respect, the paper [47] studies the relationship between the entrepreneurial orientation of universities and the search for excellence in their academic activities.

Cluster 5: Motivations of Universities to Cooperate with the Industry

This cluster focuses on the motivations of academics to complement themselves in a collaborative process with the industry. In this regard, the following stand out as motivation: the promotion of research [48] and the strengthening of student training processes [18]. In particular, the analysis of the perceptions of a group of researchers in the United Kingdom concludes that, generally, academics link up with the industry to promote their research [48]. Furthermore, the improvement of the student training process stands out as a motivation for cooperation with the industry [18]. On the other hand, the study [49] details the particularities of the collaboration process with the industry in small and medium-sized universities.

4 Discussion

We are aware that our study has important limitations. Deeper content analysis could be conducted in future studies addressing the university-company relationship. However, we consider that this bibliometric study provides important ideas to broaden the spectrum of knowledge regarding university-company collaboration in engineering.

We suggest that future studies inquire about the barriers and tensions that may arise in university-business collaboration processes, considering the objectives of each stakeholder involved. We also recommend that future studies address how SMEs can leverage university knowledge for the development of innovation processes and how they can establish more formal cooperation agreements with universities.

A future line of research that makes its way is related to the study of co-publications and co-patenting. How can researchers and entrepreneurs conduct joint research? How can a win-win relationship be established for both parties? In this line, we also propose to investigate the individual factors that affect academics getting involved in university-business collaboration processes.

Finally, based on the results of this study, we propose that future research addresses the entrepreneurial orientation of engineering students, as well as in the ecosystems of university entrepreneurship to promote technological entrepreneurship.

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An Exploratory Study into Graduate Students' Attitudes Towards Peer Assessment

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Abstract. In recent decades, many researchers have been working on the effectiveness of peer assessment in higher education. Being a useful teaching tool, peer assessment enables students to actively participate in learning and create a student-centered learning environment. Many studies focused on the influence of peer assessment on student learning, however, few studies have explored indicators that teachers can use to identify potential problems regarding students' attitudes towards students' feedback and peer review process. Thus, this is an exploratory study, trying to understand indicators for success and problems regarding students' peer feedback process. We had 93 international students performing three peer-feedback assignments (each assignment of around 2000 words and each review of at least 250 words) on the topics of digital transformation, design thinking, and leadership in an Innovation and Entrepreneurship Basic course. For each of the tasks, students completed questionnaires about their attitudes towards peer assessment in general, providing peer assessment and the usefulness of the received peer assessment. We investigate the correlation between students' performance, students' assignment lengths, and students' reviews lengths and attitude questionnaire items and we present the correlations we observed. These correlations can serve as first indicators to teachers to detect potential problems with peer assessment and get insights into student's perceptions of the peer assessment process.

Keywords: Peer assessment · Learning attitude · Essay length · Review length · Higher education

1 Introduction

Peer assessment is the process in which students grade products that have been produced by their peers [6], students consider, value and provide comments on

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products that were created by students that have a comparable level of knowledge, skill, and expertise [31]. In general, two main goals of assessment procedures can be identified: assessment for accreditation and assessment in the context of learning. In the later peer assessment and peer feedback are considered instructional strategies that have the potential to support students' domain-specific knowledge and reasoning skills [10]. Peer assessment may take on different forms. For example, by mainly focusing on the assessment in terms of grading or marking and facilitating this process through the use of rating scales and checklists. In addition to grades, peer assessment might also include written comments or feedback in which a more rich and detailed evaluation of the quality of the product and suggestions for improvement are communicated. Since the formulation of these comments invites students to engage critical reflection on the work or performance in relation to criteria this often also provides more opportunities for learning. Previous study compared three different forms of peer assessment, scoring without commenting, feedback in the form of comments, and integrated scoring and feedback [2]. Their results show that students benefited most from the assessment procedure that included integrated scores and feedback. This is partly explained by the behaviors this type of assessment induces in the learner. Students that are invited to not only grade the work of their peers have to formulate feedback that is useful for the receiver and therefore is more likely to be engaged in cognitive as well as social problem-solving processes. Research identifies potential benefits for the students providing peer assessment and feedback that are related to the behaviors the reviewing student as well as the receiving students engaging in. Reviewing students in integrated peer assessment procedures are checking the rubric to grade the work they have to assess but also compare their own work with the work of the peer they are assessing, this might also stimulate the reviewers to critically reflect on their own work [23]. Moreover, in the process of assessing and providing comments reviewers apply their domain-related knowledge and reasoning skills when they provide feedback on a product created by a peer. Reviewers also practice their communication skills in the process formulating the feedback suggestions [18]. The created feedback allows the receiving student to explore the perspective of another student.

Despite the potential benefits research findings are still inconclusive. The results of a review study show only a little evidence for learning through peer assessment in higher education, and research into students' attitudes towards peer reviewing and feedback shows mixed results [8]. Although in general students seem to appreciate peer assessment procedures, students might be hesitant to rate their fellow students [28] or provide comments because they feel that they do not have the expertise to evaluate the work or feel uncomfortable rating their fellow students [29]. Moreover, the receiving students might question the validity of the assessment [4] or usefulness of the grade and accompanying comments. This last work shows that even if checks of the peer assessment and feedback provided indicate high levels of reliability and validity from the perspective of the instructors, students still provide low estimates of the reliability and validity [4]. These issues also touch on the perceived usefulness of peer feedback in general. In their classical work on peer feedback, Ilgen et al. [12] explain that peer feedback needs to be received by the peer, accepted as accurate, perceived as useful, and should result in changes or learning. For the perception of the assessment and feedback as useful, it is important that the students have sufficient confidence in their own assessment and feedback skills and the skills of their fellow students [26]. Next to the level of confidence in the knowledge and skills, experiences with the assessor might also shape students' attitudes towards the educational benefits of the peer assessment procedure. From the content, and specificity of the comments provided the receiving student might infer the expertise level of the reviewer [5], in case of a positive impression of the level of expertise, the feedback that is provided is often considered more useful [27]. Therefore, students' attitudes towards the benefits of peer assessment might change after they have received the assessment and feedback provided by their peers.

The content of the information that students provide and receive through peer assessment might vary due to variation in the elaborateness and specificity of the comments students receive, feedback containing more clues seems to be related to higher learning outcomes [17] and is perceived as more useful by the receiving student and therefore contributes to a more positive attitude to peer assessment in general. The elaborateness and specificity of the provided feedback seem to be related to the level of expertise. Students with higher levels of expertise in the domain and good communicative skills often provide more critical and elaborate comments. Students with lower levels of expertise often refrain from detailed feedback and provide more general praise. Taking these findings into account we investigate the relationship between attitudes and perceptions related to peer feedback and assessment and students' task performance. More specifically we will explore the relationship between students' task performance, their attitude towards providing assessment and feedback, and the characteristics of the feedback they provide. As well as how the perception of the usefulness of peer assessment and feedback is influenced by general characteristics of the received assessment and feedback.

Furthermore, many previous studies have proven that the essay length can reflect on the essay's quality [13,15,30]. Therefore, in this study, we discuss the relevant factors that affect students' attitudes towards peer assessment, including assignment lengths, feedback lengths, and students' performance. These correlations can serve as first indicators to teachers to detect potential problems with peer assessment and get insights into student's perceptions of the peer assessment process.

Resulting in the following research questions. 1) What are the general attitudes of graduate students towards peer assessment? 2) What is the correlation between students' learning performance and their attitudes towards peer assessment? 3) What is the correlation between students' word counts of the assignments and their attitudes towards peer assessment? 4) What is the correlation between students' word counts of the reviews they provided, they received, and their attitudes towards peer assessment?

2 Methods

2.1 Course Structure and Assignments

The aim of the Innovation and Entrepreneurship Basics course is to enable students to:

– Get an in-depth understanding of the general process of developing an idea and starting up a new technology-based company,
– The ability to systematically explore customers and markets.
– Understand alternative technological solutions already or nearly in the market and to identify the potential value technology in the value chain of existing companies,

For its implementation the course relies on blended learning and the students are asked before the class to watch videos and like this come in class prepared [9,20]. The blending approach usually employed for this course is described in detail in [19]. Three of the sessions are fully online and are accompanied with a peer assignment, for them the students need to successfully deliver the assignments and peer reviews for the following three sessions:

Introduction to Digital Transformation students need to analyze the newspaper industry, what challenges did the newspapers industry face and how were challengers handled, which were the main technologies that enabled the digital transformation of the newspaper industry, which industry will be the next one to be digitally transformed similarly like the newspaper industry and why.

Leadership the students need to imagine that they are the project leader in a company that has at availability distributed team members in London, Mexico, and works with freelancers from Singapore, with specific profiles described in the assignment. They need to come up with a plan on how to give their client the integrated and successful solution s/he requested and to make sure all parts will seamlessly work together. One of the limitations is that instead of working on the project for 6 weeks (as would be the realistic deadline to deliver the project), the company has only 4 weeks to deliver the projects and the students need to come up with a 4-week plan for the project, define a weekly communication and exchange schedule, a team-work protocol on how and when to share information and work in progress, define feedback loops with all people involved, and identify tools to use for coordination of the personnel

Design Thinking students need to analyze the water shortage issue, an introductory text that contains relevant observations was given as a starting point and then the students needed to analyze the given points, form two insights and learn from them, and use the "How might we... question" to solve the problem.

As part of the peer-review process, besides providing feedback on how to improve the assignment (based on specifically designed rubrics for each of the three assignments), students also provided marks to their peers on a scale from

0 to 100 to each other. In this paper we analyze and we investigate correlations between, the mark provided, the lengths of assignment and length of assessments, with the student's responses of the scales on attitudes (see details in subsection Measurement).

2.2 Participants

All the participants are 1st year Master's degree students in computer science coming from different Computer science specializations. The students were assigned randomly and were asked to review. The total number of students was 93 with 67 males and 26 female students. All the participants were inquired for consent before filling out the surveys.

2.3 Measurement

An assessment suite consisting of three questionnaires that assess attitude: 1) right after submitting the assignment, i.e. before providing peer assessment on general attitude towards peer review 2) after providing feedback on an assignment of a peer, a questionnaire on attitude towards providing peer review 3) after receiving feedback, a questionnaire on the perception of the received feedback. All three scales of the questionnaire are based on existing questionnaires and include items that focus on peer assessment as well as the accompanying feedback, to match the set-up of students' peer assessment experience that included not only grading but also required to provide feedback. According to Cronbach's alpha test, the reliability of the survey is 0.93. The items of all three scales can be found in Table 1.

General Attitude Questionnaire. This questionnaire was designed to measure the attitude to peer reviewing and assessment with respect to a specific task. The questionnaire consisted of 12 items that were based on the work of Huisman [11] and Roskams [25].

Attitude Towards Providing Feedback. After reading the assignment and providing feedback students were asked to complete a scale consisting of 4 statements that should be rated on a 5 point scale ranging from 1 (completely not applicable to me) to 5 (completely applicable to me). Three statements referred to their perceived ability to provide fair and useful assessment to their peers (e.g. I could make a fair assessment of my peer).

Perception of the Received Assessment. After receiving the grades and feedback the receiving student completed a short questionnaire, consisting of 4 statements that focused that addressed the perceived fairness, usefulness and, quality of the received comments.

2.4 Procedure

All the assignments had the same deadline, December 1st, 2019. After the students finished the delivery of the assignment, the first survey was delivered aimed

Table 1. Students' scores in the attitude scales

Item	Statement	M (SD)
1	I understand the content of this course	4.16 (0.89)
2	I have enough content related knowledge to provide meaningful peer feedback	3.83 (0.97)
3	I have the skills needed to provide meaningful peer feedback	3.87 (0.90)
4	I understand the feedback criteria provided to me by the teacher	3.76 (1.15)
5	I think peer assessment is a fair method to assess students' performance	3.28 (1.24)
6	I believe that it is very important for me to learn how to participate in peer assessment	3.95 (1.07)
7	Involving students in feedback through the use of peer-feedback is meaningful	3.75 (1.08)
8	Peer-feedback within the course is useful	3.64 (1.12))
9	Feedback should only be provided by the teaching staff	3.03 (1.32)
10	Being capable of giving constructive peer-feedback is an important skill	4.46 (0.74)
11	Being capable of dealing with critical peer-feedback is an important skill	4.56 (0.72)
12	Being capable of improving one's work based on received peer-feedback is an important skill	4.54 (0.62))
13	I could make a fair assessment of my peer	4.19 (0.90)
14	I learned useful skills by assessing other students and giving comments	3.85 (1.10)
15	In general, I am confident that the peer-feedback I provide to other students is of good quality	4.07 (0.86)
16	In general, I am confident that the peer-feedback I provide to other students helps them to improve their work	3.98 (0.89)
17	Peer assessment was fair to me	3.98 (1.03)
18	The comments made by the peer assessor made sense and potentially could improve my work	3.85 (1.06)
19	In general, I am confident that the peer-feedback I receive from other students is of good quality	3.82 (1.10)
20	In general, I am confident that the peer-feedback I receive from other students helps me to improve my work	3.75 (1.14)

to measure the attitudes towards peer review for the given task. The deadline for providing peer review for the three assignments was December 15th, 2019 after which immediately the second questionnaire was delivered aimed at understanding attitudes of the students towards providing feedback. The reviews were opened to the students and they could start consulting them on December 27th, 2019, and students needed to fill in the last questionnaire at the latest by January 15th, 2020. All the surveys were collected via SurveyHere (www.surveyhero.com) platform.

3 Results

3.1 Students' Responses in the Attitude Scales

The purpose of this study is to explore the graduate students' attitudes towards peer assessment. According to the results in Table 1, the average of all items is 3.92, which indicates that students generally have a positive attitude towards peer assessment. Although the students' attitudes towards peer assessment varied in different assignments, on average, items 10, 11, 12, 13 valued the most while 5, 8, 9 valued the least by them in the attitude scales.

We further observed items with higher average scores. The results in Fig. 1A reveal that students mostly valued peer-feedback skills, including providing constructive suggestions, handling critical reviews, and improving their work based on the reviews they received. Moreover, students commonly believed that they can provide fair peer assessment. In the above items, only less than 5% of the students expressed disagreement or inapplicability. Furthermore, about a quarter of the students didn't believe the fairness of peer assessment (Fig. 1B), and 15–18% of the students have denied the usefulness of applying peer assessment in the classroom (Fig. 1C). Besides, 37%–42% of the students considered that feedback for their assignments can only be provided by the teaching staff instead of peers, as shown in Fig. 1D.

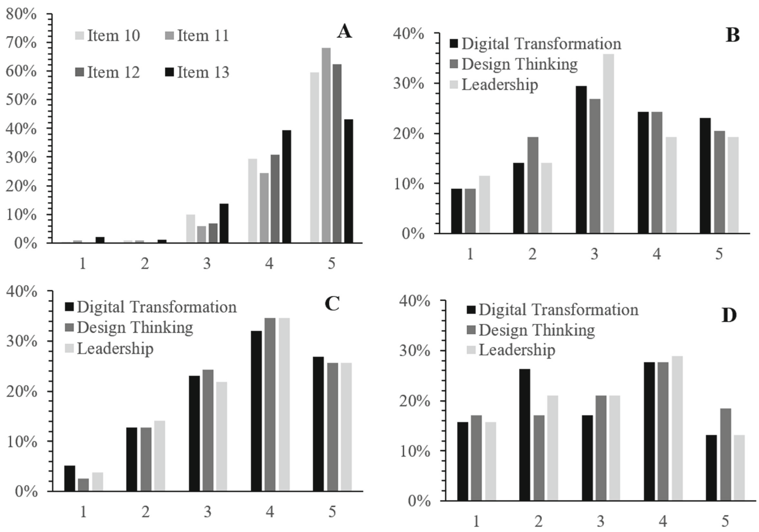

Fig. 1. 1A: the percentage of students' numbers of each score in items with higher average scores. 1B, 1C, 1D represent items 5, 8, 9 respectively. Item 9 is a reversed item that score 5 indicates completely disagree with the content of this item

3.2 The Correlation Between Assignment Grades and Scale Scores

In order to explore the correlation between students' performance and their attitudes towards peer assessment, we used Pearson's chi-squared test to examine the relation of assignment grades and the scores in the attitude scales. The results of the study showed that students' grades for each assignment and the average scores in the entire scales were not significantly related (data not shown). However, we found that there was a positive correlation between certain items in the attitude scales and assignment grades. From the statistical results in Table 2, we can see that the average grades for all assignments are positively correlated with items 9, 10, and 11 in the attitude scales. The result reveals that the lower the students' average grades were, the more likely the students thought that the comments can only be given by the teaching staff. Moreover, students with higher grades tend to value the skills of giving constructive comments and dealing with critical ones. Similar results can also be observed in the assignment of digital transformation. As for the assignment of design thinking, the better grades the students got, the more likely they perceived the meaningfulness of peer assessment (see item 7). However, there is no significant correlation between the assignment grades of leadership and their scores of each item in the attitude scales.

Table 2. Pearson correlation between students' grades and scale scores.

	Item 7		Item 9		Item 10		Item 11	
	r	p	r	p	r	p	r	p
Digital Transformation	.139	.217	.195	.088	.264*	.018	.279*	.012
Design Thinking	.231*	.042	.125	.277	.047	.680	.052	.648
Leadership	.037	.741	.140	.211	.164	.146	.144	.202
The average of three assignments	.073	.524	.248*	.028	.250*	.027	.224*	.049

*Correlation is significant at the .05 level (two-tailed). Note: r: the value of Pearson' r, p: 2-tailed significance value. Items without significant correlation are not shown in this table.

3.3 The Correlation Between the Word Counts of Assignments and Scale Scores

We further explored the correlation between the word counts of students' assignments and their scale scores. As shown in Table 3, the average scores of all items in the three scales are positively correlated to the word counts of the assignments of design thinking and leadership. However, as for the assignment of digital transformation, no significant correlation was found. We then examined the relationship between word counts and the scores of the attitude scales submitted at different time phases (before providing feedback, after providing feedback, and after receiving feedback). In the first-time phase, students who wrote more words in the assignment of design thinking and leadership tend to score higher in the attitude scales. The first scale is mainly designed to evaluate the importance of peer assessment to students. From these two assignments, it can be seen that the students with more written words in these assignments valued the importance of peer assessment more. Then, the second scale only shows a significant correlation between students' word counts of the assignment of leadership and their scale scores. The items in the second-time phase were mainly designed to ask students whether they could provide high-quality feedback. From our analysis, it seems that the more words students wrote in the assignment of leadership, the more likely they believed they could provide high-quality feedback as well. In terms of the result of the third scale, it seems that the more words students wrote in the assignment of design thinking, the higher scores they got. The items in the third scale are mainly related to students' perception about the quality of the feedback receiving from peers. Thus, we can know that the more words students wrote in the assignment of design thinking, the more likely students appreciated the quality of the comments given by peers. It is worthy to note that the word counts of each assignment were significantly related to the assignment grades and the word counts of feedback given to peers.

3.4 The Correlation Between the Word Counts of Peer Assessment and Scale Scores

We also explored the correlation between students' word counts of peer assessment and their scale scores by dividing the data into two parts. The first part was to examine the relation between students' word counts of reviews they gave and

Table 3. Pearson correlation between word counts, grades, and scale scores.

	Grades	Giving Review	All	Scale I	Scale II	Scale III
Digital Transformation						
Pearson Correlation	.296**	.290**	.117	.156	.116	−030
Significance (two-tailed)	.008	.010	.306	.169	.309	−790
n	79	79	79	79	79	79
Design Thinking						
Pearson Correlation	.364**	.349**	.253*	.232*	.125	.243*
Significance (two-tailed)	.001	.002	.025	.041	.277	.032
n	78	77	78	78	78	78
Leadership						
Pearson Correlation	.303**	.389**	.260*	.270*	.263*	.243*
Significance (two-tailed)	.007	.000	.020	.016	.019	.373
n	79	79	79	79	79	79

*Correlation is significant at the .05 level (two-tailed). **Correlation is significant at the .01 level (two-tailed) Note: 'All', 'Scale I', 'Scale II', 'Scale III' shown in the table respectively represent the average scores of all items, the items before providing peer assessment, after providing peer assessment, and after receiving peer assessment from peers in the scales.

their second scale scores. The second part mainly focused on the relation between students' word counts of the reviews they received and their third scale scores. The results in Table 4 indicate that only the leadership assignment shows a significant correlation between the word counts of the peer assessment and scores in items 16, 18, and 20 of the scales. In this assignment, the more the review words students gave, the more likely they are confident to provide high-quality reviews. Similarly, the more review words they received, the more possible they trusted the quality of the reviews. It seems that students determined the quality of the given leadership reviews based on the number of words. However, no significant correlation was found in the other two assignments.

4 Discussion

The aim of this study was to perform an exploratory investigation of factors that influence attitudes towards peer review assessment in graduate students. We employed correlations to explore discover patterns of dependencies between the different factors we took into account, the aim of future work is to use regression analysis to check the relationship between performance and attitudes.

4.1 Students' Attitudes Towards Peer Assessment

According to the results of the students' responses in the scales, the vast majority of the students regarded peer assessment as an important skill. On the other hand, although most students had positive attitudes towards cultivating peer assessment skills, some still disagreed with the usefulness of applying peer assessment in the context of this master course. Interestingly, some students were doubtful about the fairness of peer assessment even though most students perceived that they can provide fair feedback, which is consistent with the result of previous research [25]. This might be because these students were first-year

Table 4. Pearson correlation between word counts of peer assessment and scale scores

	Giving Review		Receiving Review			
	Item 16		Item 18		Item 20	
	r	p	r	p	r	p
Digital Transformation	.189	.095	.039	.735	.037	.749
Design Thinking	−.054	.638	.017	.883	.095	.408
Leadership	.222*	.049	.234*	.038	.248	.029
The average of three assignments	.125	.274	.142	.214	.161	.160

*Correlation is significant at the .05 level (two-tailed). Note: Giving Review: the word counts of peer assessment given to peers. Receiving Review: the word counts of feedback received from peers. r: the value of Pearson' r. p: 2-tailed significance value. Items without significant correlation are not shown in this table.

graduate students who lacked the experience of face-to-face cooperation, they did not establish trust in their relationship. Thus, they considered that only the teaching staff is qualified to provide feedback to students.

4.2 The Correlation Between Students' Performance and Attitudes Towards Peer Assessment

According to Pearson Correlation analysis, the correlation between students' performance and their attitudes towards peer assessment would vary depending on the topic of the assignment. Overall, students who performed better tend to support that feedback can also be given by people other than the teaching staff. Moreover, students with better performance pay more attention to the cultivation of peer-feedback skills, especially for the digital transformation assignment. It is worth mentioning that in the design thinking assignment, the better the students performed in the assignment, the more likely they perceived the meaningfulness of peer assessment.

4.3 The Correlation Between Students' Assignment Lengths and Attitudes Towards Peer Assessment

The results suggest that in addition to students' performance, their assignment lengths also are positively correlated to their attitudes towards peer assessment. Surprisingly, as for the assignments of design thinking and leadership, the correlation between assignment lengths and students' attitudes towards peer assessment is much greater than their performance and peer-feedback attitudes. However, there is no significant correlation shown in the assignment of digital transformation. It may be because the design thinking and leadership assignments were designed to cultivate students' entrepreneurship which requires them to work in groups. However, as for digital transformation assignments, students can accomplish their assignments by figuring out the theories and models themselves without having group discussions. Nevertheless, the results indicate a difference between the assignments of design thinking and leadership. In the assignment of leadership, students with longer assignment lengths tend to be confident in providing higher-quality peer feedback. Considering that students' assignment lengths were significantly correlated to their grades, students with longer assignment lengths might indeed have the potential ability to provide constructive and valuable advice to help peers improve their work. On the other hand, as for the assignments of design thinking, students writing more to express their thoughts were more likely to believe that peer-reviewed opinions can assist them to improve their work. Besides, we noticed that students' assignment lengths reflected on their performance. It is probably because the more detailed the students elaborated on their work, the more likely they can express their ideas clearly and thoroughly, which leads to higher-quality essays. However, it still needs further analysis to validate whether a longer essay or feedback can demonstrate a better-quality argument. Also, the students with longer assignments generally offer longer feedback to peers as well.

4.4 The Correlation Between Students' Feedback Lengths and Attitudes Towards Peer Assessment

The content of the assignment of leadership is mainly to discuss how if the student is a leader, he will lead the team forward with time constraints. The result indicates that students considered that the longer the comments were, the better the arguments were for issues related to teamwork. However, the relationship between students' feedback lengths and their attitudes towards peer assessment is not shown in the assignments of digital transformation and design thinking.

4.5 General Impressions and Learnings from the Course

In general, we observed that the students scored high on the assignments. In our view what contributed to this was that the rubrics of the assignment were quite clear in this respect and for instance if the assignment is asking the students to give two examples of something, the rubrics asked the reviewer 'did the peer provide 2 examples?' This might have resulted in students giving points for finishing the job without taking the quality of the work into account. Most students received high points for the assignments. Looking into the log files, we found out that mainly students that wrote the assignment last minute received lower points or no points at all. This might be due to the fact that these students did not take the time or have the time to check the requirements. Based on these findings and observations, we conclude that in a MOOC like learning environment, that was alike in our study, the design of the instruction and the rubric should inspire in-depth elaboration and not mainly serve as an easy checklist. Participants in our study were not informed about the potential benefits of the peer assessment procedure and did not receive instructions on peer assessment and providing feedback. Results of a recent meta-analysis [14] into the effects of peer assessment reveals that training in peer assessment is often associated with higher learning effects. In future editions of the course, this will be implemented and effects will be evaluated.

We also believe that from this work and this data set that we have created for this study, we can draw interesting conclusions for the development of entrepreneurship skills and competencies and how much actually peer-review assignments online can help (or not) the development of them. Other works have looked in this direction too, that is if peer review can be used to determine development of soft skills [21]. We observed that the students felt freer to give feedback and usually wrote more in the Design Thinking and Leadership assignments, while usually their feedback was more contained in the Introduction to digital transformation session. We believe that this was due to the different nature of the assignments, and while the Introduction to the digital transformation required the reviewer to comment on an assignment submitted by the peer on key technologies that enabled the digital transformation for the newspaper industry or what were the challenges the industry faced (based on their knowledge gained), the other two asked the students to provide critique or review of a potential solution the peers needed to come up on their own, and we believe that both in these respect, the assignments and the peer reviews highly depended on the entrepreneurship skills and competencies developed by the students. It would be a further experiment to design with standardized questionnaires to use for this that will help us measure if this was the case or not.

5 Conclusions

With this study, we explore indicators that teachers can use to identify potential problems regarding students' attitudes towards students' feedback and peer review and indicators for success and problems regarding students' peer feedback process. These indicators can be used to detect potential problems with peer feedback and get insights into student's perceptions of the peer feedback process.

5.1 Conclusions

This study aims to explore students' attitudes towards peer assessment, as well as the relationship between their performance, their assignment lengths, their feedback length, and their attitudes towards peer assessment. The results indicate that students generally have positive attitudes towards peer assessment, which is consistent with previous research [1,3,16,22,25]. Moreover, even though most students emphasize the importance of developing peer-feedback skills, some students still denied the usefulness of peer assessment. It might be because students do not have enough confidence in their peers' feedback skills as well as the level of expertise [26,27]. The situation that the students do not have sufficient confidence in their peers also reflects on their perceived fairness of peer assessment. Cheng and Warren [3] also mentioned that students doubt their objectivity while assessing their peers, since they are more likely to mark higher scores to peers who treat them friendly. Furthermore, students are used to being graded by teachers, so they tend to trust the reliability of teachers' ratings more than the peers' [16,25]. Similar results can also be seen in our study, in which many students considered that only teachers are qualified to give feedback to them. The same study [3] pointed out that students thought the ratio of teachers' ratings to students' ratings should be 3:1, and our results confirm this statement. This approach can help students gradually change from teacher-centered to student-centered learning. Teachers can also provide rubrics as grading criteria for students to follow.

This study indicates that students' performance will reflect on their attitudes towards peer assessment, especially for the peer-feedback skills. The length of the assignment was also highly correlated to the student's performance and his attitude towards peer assessment. Many previous studies have proven that the essay length is positively correlated with the student's performance [13,15,30], which implies that essay length can indeed reflect on the essay's quality. Also, it is worth to mention that as for the leadership assignment, longer feedback tends to be more likely considered as high-quality feedback. It might be because students with longer comments were more likely to accurately clarify their views. Other works also stated that students benefited from the peers' perspectives in the feedback [18], and our study confirms that as well.

5.2 Future Directions

This study used an innovation and entrepreneurship course in computer science curriculum as a case to explore students' attitudes towards peer assessment and the correlation with performance. The research results indicated that students had different attitudes towards peer assessment in the different topics of assignments. Obviously, students' attitudes towards peer assessment would be affected by the topic of the assignment. Thus, we suggest extending the research of peer feedback and assessment to other scientific subjects in the future to observe whether the phenomena will be similar or different.

The researchers used Pearson's correlation to initially analyze the collected data in this exploratory study for graduate students' attitudes towards peer assessment. In the future, regression analysis will be used to further explore the interplay of the students' performance and their attitudes toward peer assessment. Moreover, in our current study, students' assignments were graded by their peers based on the rubrics given by the teacher. There is a potential for the teaching staff to reformulate the rubrics based on the learning objective of each topic and re-grade the students' assignments, so that we can compare these two ways of performance assessment.

Furthermore, the relevance of feedback length to feedback quality is worthful to do further research as well. According to previous studies, the review quality can be examined from three aspects: 1) giving comments according to the rubrics given by the teacher. 2) evaluating peers' work (criticism or praise) with specific examples. 3) providing constructive suggestions to help peers improve their work [7,24].

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Activities to Explore the Entrepreneurship Mindset at the Higher College for Engineering Wolfsberg, Austria

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Abstract. We are living in a very fast and globalized world. Students should be prepared for the future and more extensive requirements in the labour market. Basic competences acquired during the obligatory lessons are not sufficient anymore. Students need entrepreneurial skills like the ability to work in teams, a sense of responsibility and self-reliance, as well as organizational skills. These skills also need to be interdisciplinary.

That's the reason, the Higher College for Engineering Wolfsberg (short "HTL Wolfsberg") is forcing entrepreneurial activities to prepare the students for the future. The aim is that everyone should gain the key set of competences needed for personal development, social inclusion, active citizenship and employment.

We increasingly focus on business games and participation in competitions.

Furthermore, cooperations with business experts and funding agencies enable valuable input for our students. This guarantees good support for the entrepreneurs of the future.

Due to the COVID 19 situation we were forced to practice distance learning. It is hard to imagine entrepreneurial subjects can be teached online – but we broke new ground with specific online games.

This paper gives an overview on activities and didactical approaches used by the Higher College for Engineering Wolfsberg within the last years in order to explore the entrepreneurial mindset of their students.

Keywords: Entrepreneurship · Business games · Didactical approaches · Gamification · Competitions

1 Entrepreneurship Education

1.1 Entrepreneurship Education in the EU

The development of the entrepreneurial capacity of European citizens and organizations has been one of the key policy objectives for the EU and member states for many years. There is a growing awareness that entrepreneurial skills, knowledge and attitudes can be acquired and in turn lead to the widespread development of entrepreneurial mind-sets and culture, which benefit individuals and society as a whole.

The European Commission first referred to the importance of entrepreneurship education in 2003, in the European Green Paper on Entrepreneurship in Europe. By

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2006, the European Commission had identified a ‘sense of initiative and entrepreneurship’ as one of the eight key competences necessary for all members of a knowledge-based society. The 2008 Small Business Act for Europe, the 2012 Communication on Rethinking Education, the 2013 Entrepreneurship Action Plan 2020, and more recently the New Skills Agenda for Europe, have kept the need to promote entrepreneurship education and entrepreneurial learning under the spotlight. This has led to a wealth of initiatives across Europe.

As highlighted in the 2016 edition of the Eurydice Report on ‘Entrepreneur-ship Education at School’, about half the countries in Europe make use of the European Key Competence definition of entrepreneurship. A third of the countries use their own national definition and almost 10 countries have no commonly agreed definition at national level. Furthermore, the lack of comprehensive learning outcomes for entrepreneurship education is identified by Eurydice as one of the main hindrances to the development of entrepreneurial learning in Europe.

As a result, there is a clear need to define and describe entrepreneurship as a competence; to develop the reference framework describing its components in terms of knowledge, skills and attitudes; and to provide European citizens with the appropriate tools to assess and effectively develop this key competence [1].

1.2 Entrepreneurship as a Competence

EntreComp – The development of the entrepreneurial capacity of European citizens and organizations is one of the key policy objectives for the EU and Member States. Entrepreneurship was defined as one of the 8 key competences necessary for a knowledge-based society.

In the context of the EntreComp study, entrepreneurship is understood as a transversal key competence applicable by individuals and groups, including existing organizations, across all spheres of life. It is defined as follows:

Entrepreneurship is when you act upon opportunities and ideas and trans-form them into value for others. The value that is created can be financial, cultural, or social (FFE-YE, 2012).

This definition focuses on value creation, no matter what type of value or context. It covers value creation in any domain and possible value chain. It refers to value creation

Fig. 1. Entrecomp model of the EU

in the private, public and third sectors and in any hybrid combination of the three. It thus embraces different types of entrepreneurship, including intrapreneurship, social entrepreneurship, green entrepreneurship and digital entrepreneurship [2] (Fig. 1).

'Ideas and opportunities', 'Resources' and 'Into Action' are the 3 areas of the conceptual model and have been labelled to stress entrepreneurship competence as the ability to transform ideas and opportunities into action by mobilizing resources. These resources can be personal (namely, self-awareness and self-efficacy, motivation and perseverance), material (for instance, production means and financial resources) or non-material (for instance, specific knowledge, skills and attitudes). The 3 competence areas are tightly intertwined: entrepreneurship as a competence stands above all three of these together. The 15 competences are also interrelated and interconnected and should be treated as parts of a whole. We are not suggesting that the learner should acquire the highest level of proficiency in all 15 competences or have the same proficiency across all the competences. The framework does, however, imply that entrepreneurship as a competence is made up of 15 building blocks [2].

1.3 Certificate for Entrepreneurship Education at Colleges for Engineering in Austria

In 2010, the Austrian Federal Ministry of Education established a federal working group, named "Entrepreneurship for Engineers" (Entrepreneurship Education at Higher Technical Colleges). Members of this working group are teachers from all nine federal states in Austria. After some years working on a common understanding of entrepreneurial contents for engineering students, several institutions decided to work together. This was done in order to ensure that the entrepreneurship activities of the school sites are realistic, practice-oriented and scientifically justified. The institutions cooperated to develop and define a certification criteria and a certification process for entrepreneurship education at colleges for engineering. The following institutions are involved in the certification process for becoming a "Competence Center for Entrepreneurship Education in Engineering" certified by IGIP.

- Certification organization: IGIP - International Society for Engineering Pedagogy):
- Scientific partner: Graz University of Technology, Austria
- Operational unit: Federal Working Group Entrepreneurship for Engineers (Austrian Federal Ministry of Education)
- Quality Assurance institution: An Entrepreneurship for Engineering "mentor": an experienced entrepreneur, who has to accompany the school site over the whole schoolyear
- A special audit team formed out of theses partners make sure that the defined criteria are met.

One important aspect of this specific certification is that not only the school itself is certified, but they also get the permission to hand over certificates to their students if they meet certain criteria. 27 students from the HTL Wolfsberg received this certificate within the last 4 schoolyears.

The HTL Wolfsberg was the first college for engineering to pass this audit in 2016. In the meantime, five other Austrian colleges for engineering are also hold the certificate.

2 Overview of Didactical Approaches and Recent Activities at the College for Engineering Wolfsberg

2.1 Board Game "Create Products"

The board game "Create Products" was developed by three members of the Austrian federal working group "Entrepreneurship for Engineers". It is focused on the early stage of idea generation of the product development process and aims at getting students more interested in creativity techniques. Four creativity tools (brainstorming, emotive words, inventive principles and trends of evolution) must be used for generating ideas for a further product development of well-known products.

The game concept was presented at the ICL conference 2019. See paper "Entrepreneurship Game Concept "Create Products" - Idea generation for product development with a board game".

"Create Products" is used in subjects like "entrepreneurship education" or "innovation and product development" at the HTL Wolfsberg. According to our experiences the students like this game a lot.

2.2 Online Simulation "Stratopoly"

The HTL Wolfsberg has been successfully using business simulation games and "simulations" (board games, Lego and workplace simulations) in the classroom for years. This is an attempt to introduce the students to business basics and important aspects of entrepreneurial (strategic) decisions in a playful way. In this way, the pupils can repeat what they have already learned in a playful way and usually understand it better than without simulations. In addition, practical experiences on topics such as income statement, balance sheet, cash flow, investments and important business indicators such as ROS, ROI, ROE are gained.

Even in times of distance learning, attempts were made to continue this type of teaching and to expand it with new approaches. The students adapted very quickly to the current situation and settled well in with e-learning.

https://www.stratopoly.de/

The online entrepreneurial simulation game Stratopoly (especially for the specializations of industrial engineers) was purchased for the laboratory lessons of our school, especially in the area of "entrepreneurial thinking/entrepreneurship". The students' economic relationships and entrepreneurial decision-making skills are promoted. During the online lessons, caused by COVID-19 pandemic, around 60 students at HTL Wolfsberg gained experience with the game "Stratopoly" and, took responsibility for the areas of purchasing, production, sales, marketing and financing. In doing so, they had to assert themselves against their competitors in order to ultimately achieve the highest possible company value. This strategy game is played over several rounds, each representing a financial year. After each round, the game result is published, and new decisions are made in all areas of the company. The competition motivates the pupils to learn new strategies and to face the entrepreneurial challenges. This way, entrepreneurial thinking and understanding of the effects of entrepreneurial decisions are fostered.

Due to the positive feedback by the students, we will continue this form of learning in laboratory lessons in the future.

Below some students' questions answers, taken from the online feedback, can be found:

1. Question: How realistic was the game to you?
• "Very much because you have a lot to do with numbers and you also have to work every day. You have to place orders for the grapes, because otherwise you cannot produce, and that means you build losses because the fixed costs always remain the same."
2. Question: Explain how you have managed your company over the 13 years and which strategies you have chosen?
• "To grow continuously in small steps with relatively little debt.
• In the beginning, in order to be able to produce medium-quality wines, I limited my total fixed costs to the bare minimum. Changes have also been made to the staff to get the best possible start. My goal was to be a serious competitor in the wine industry."
3. Question: How did you like the game, would you play it again, and in which items do you think it could be used?
• "I would play it again because it promotes economic thinking. I would not recommend any special items for this game, because in my opinion everyone, whether computer scientist or mechanical engineer, should play it once. Because you learn to run your own company, and I think that's important for the future."
4. Question: What did you learn from this business simulation game?
• "Entrepreneurial thinking, planning and investing money properly.
• How much to consider when running a company.
• That one should be fixated on a strategy. Either you specialize in quality OR quantity."
5. Question: How did you do with corporate management? Have there been any surprises you didn't expect?
• "If you don't take a look, you are pretty much in the red. One must not lose track and control."

2.3 Business Game "inspire! Build Your Business"

In order to create new ways of thinking and perspectives, we use innovative methods of knowledge transfer. One of them is the "inspire! build your business" game. In this business game, we build entrepreneurial skills through innovative, playful ways. The game simulates the path from brainstorming to implementation of the business model.

Starting points of the business game are real ideas by innovative start-ups from Austria and are prepared as mini case studies.

The entrepreneurial practices are experienced by the students themselves. They take on roles as entrepreneurs or investors. This way, real business ideas are critically reviewed and developed further. A reflection at the end of the game combines theory and practice. Through the game, theoretical concepts such as open innovation or lean start-up or design thinking become fast and simply applied [5].

The inspire! game can be played in different ways of duration and is divided into 4 sessions. This makes it possible to implement the game into the classroom quite easily. The response and feedback of all participants was very positive (Fig. 2).

inspire! BUILD YOUR BUSINESS

Fig. 2. inspire! game @ HTL Wolfsberg

2.4 Business Simulation “Factory” and “Global Strategy”

Business topics concerning accountant activities like balance sheet, profit and loss statement as well as financial/business key indicators are quite boring for most of the students, if taught in a normal classroom environment.

In order to bring some more action and fun to the students, the teaching faculty of the HTL Wolfsberg decided to use business simulations (mostly board games) in their lessons. After a short market screening, which was done together with another College for Engineering two simulations were purchased from the company BTI in Germany.

The business simulation “Factory” focuses on the understanding of the key performance indicators of a production enterprise, mainly ROI (return on investments), ROS (return on sales) and (CT) capital turnover. Their dependency and the influence of numbers from the balance sheet are reenacted in three game rounds in a very realistic way.

This simulation has been used at the HTL Wolfsberg for five schoolyears now. The feedback by the students was very positive and ensures a basic understanding of the operational performance process and the importance of key performance indicators (Fig. 3).

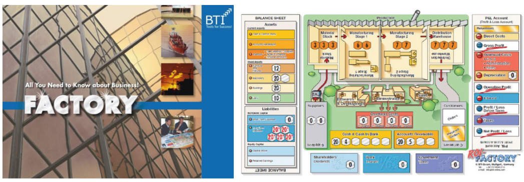

Fig. 3. Simulation “Factory” and the “Factory” playground

"Global strategy" is the name of the second simulation of the same German company. This simulation also allows to simulate the competitive situation on the market. Several teams are formed and represent competing companies on the market. The teams need to make strategic decision in the field of product and market development as well as investments in production equipment etc. The challenge of this simulation for a school is that it needs quite more time to be played.

2.5 Card Game "Digital Excellence"

https://digitalexcellence.at/

The "Digital Excellence Navigator" is a practice-oriented methodology to build up knowledge about digitization, to develop specific project ideas and strategies together in a team and thus guarantee an active implementation.

The game can be played with preexisting companies or you can use your own company. Play cards give you impulses to develop the digital business model.

The strategic and operational challenges are then worked out on a specially developed journey canvas and the relevant digitization ideas and initiatives are derived from them. The effects on the possible corporate strategy and vision of the company are checked and adjusted if necessary [6].

This game will last approximately 4 h and every time the students play it, it becomes more interesting (Fig. 4).

Fig. 4. Business model canvas

2.6 Participation in EU Projects

Since 2010 the College for Engineering Wolfsberg has taken part in European funded programs, especially Erasmus + and Interreg projects. Ten project submissions, beside mobility projects in Erasmus +, have been successfully conducted within the last 10 years.

Several of these European projects have a more or less clear focus on entrepreneurial topics, four are mentioned below:

- Project "E-Edu 4.0" (Engineering Education 4.0) Funding program: Interreg IT-AT (Italy – Austria)

Project number: ITAT3018
Duration: 05/2018–04/2021 (postponed COVID-19)
Project partner from Italy

- Project " Factory Labs" Funding program: Interreg SI-AT (Slovenia – Austria)

Project number: SI-AT-3–1-076
Duration: 04/2013–05/2014
Project partner from Slovenia

- Project "School Companies" Funding program: Erasmus+/KA2

Project number: 2016–1-PL01-KA219–026118
Duration: 10/2016–09/2018
Project partners from Poland, Germany and Romania

- Project "Skills4Life" Funding program: Erasmus+/KA2

Project number: 2016–1-ES01-KA219-024933_7
Duration: 09/2016–08/2019
Project partners from Spain, Croatia, Cyprus, France, Poland and Portugal

3 Overview of Recent Participations at "Entrepreneurial" Competitions by the College for Engineering Wolfsberg

3.1 Junior Achievement – JA Austria - Junior Companies

JA Europe is the largest non-profit organization in Europe dedicated to preparing young people for employment and entrepreneurship. JA Europe is a member of JA Worldwide®, who have delivered hands on, experiential learning in entrepreneurship, work readiness and financial literacy for 100 years. JA creates pathways for employability, job creation and financial success [7]. Last school year, the JA network in Europe reached more than 4 million young people across 40 countries with the support of 140,000 business volunteers and 130,000 teachers/educators. Every year we have at least one junior company at our school. That way we are also part of that network (Fig. 5).

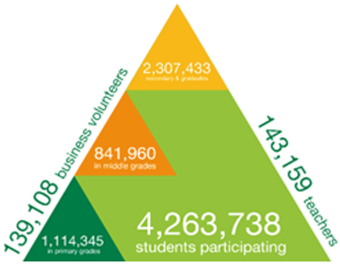

Fig. 5. Junior Achievement Europe

Junior Companies at the HTL Wolfsberg of the last 2–3 years (Figs. 6 and 7):

- Schoolyear 2017/2018/19:

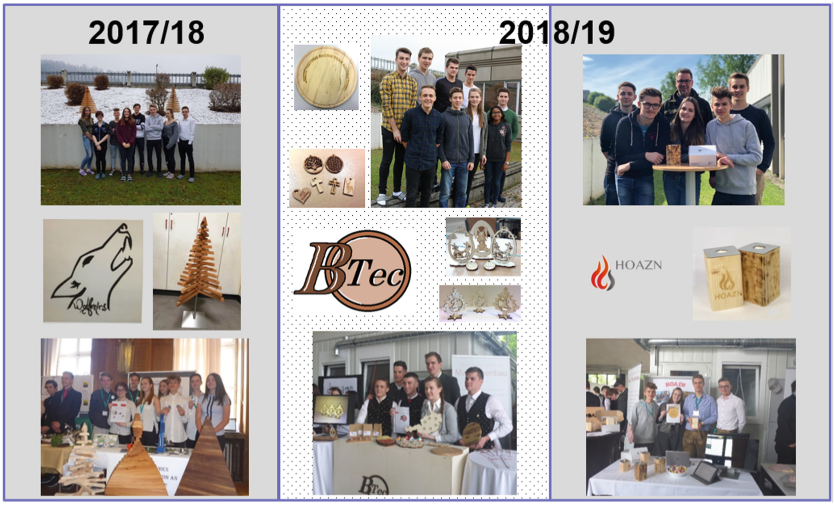

Fig. 6. Junior companies 2017–2019

- Schoolyear 2019/20:

Fig. 7. Tom and J Junior Company

Our this year's junior company developed innovative salt and pepper shaker with customized individual laser print.

According to the feedback of the students their company was like in real business life - the team had to endure ups and downs during the project. Nevertheless, the students have been highly motivated and the output and success of all the company paid off for all the exertions.

3.2 SkillsAustria (Federal Championships in Entrepreneurship Education)

The national secretary within the Economic Chamber organization, SkillsAustria coordinates the Austrian state competitions which are held to qualify candidates for WorldSkills and EuroSkills. This is organized in cooperation with the federal guilds and professional associations of the federal sections for Crafts and Trade; Tourism and Leisure; Industry; Information and Consulting; as well as with the various VET schools and colleges. In January 2020 two students of the HTL Wolfsberg took part in the Austrian Skills Championship in Entrepreneurship! (It was already the second time – after 2018 - that a team of the school participated in this competition).

The championship competition lasts 2 days and the attendees have to build up a business model and all elements of a business plan for a business idea.

The basis is a random election of one of the 17 SDG's (Sustainable Development Goals). For this SDG a basic product or business idea has to be developed and for this idea all elements for a business plan have to be worked out and presented by the students. Our teams chose SDG No 5 which stands for "Gender Equality". The two students developed a business idea to connect elder and younger people to get IT support. After the final pitch our team reached the 4th place.

3.3 Moonshot Pirates

Encouraging young minds to dream big & to walk their own path by fostering moonshot thinking & sparking the entrepreneurial spirit is another important topic for our students.

We live in one of the most exciting times in history. Now and for the decades to come, everyone has the opportunity to contribute to shaping the future world. It's up to every person to create their one future. "Moonshot Pirates" don't care about conventional rules and limits. They follow their own paths. An important feature for them is to leave a positive impact on the planet and modern society.

The challenge is based on a 3-day bootcamp and includes the following content (Figs. 8, 9 and 10):

Fig. 8. Bootcamp day 1

Fig. 9. Bootcamp day 2

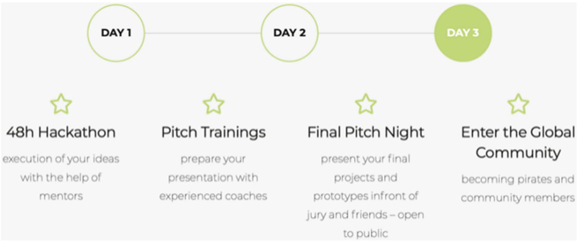

Fig. 10. Bootcamp day 3

One team of the HTL Wolfsberg took part at the bootcamp in Tainach (Carinthia) and reached the first place out of 35 competitor teams.

After additional coaching sessions and expert advice, they founded their own business and are already quite successful, even before graduating from school.

In the meantime, the two students have also been invited to take part in a new TV-show format of the German/Austrian TV channel "Puls4". The title of the is "2 min – 2 mentors". The episode has already been recorded and should be broadcast in autumn 2020 (Fig. 11).

Fig. 11. Team “Gratos” at the “Pitch Night”

4 Results and Conclusion

The HTL Wolfsberg’s activities in the area of entrepreneurial education, the promotion and acting of entrepreneurial thinking of its students and teachers as well as the cooperations with companies were honored with the award “The Entrepreneurial School 2020”. This award recognizes Europe’s best schools in the implementation of “Entrepreneurship Education” and has been awarded for the sixth time by “Junior Achievement Europe”.

For each EU country only two schools are awarded. In addition to that, the HTL Wolfsberg is also nominated for a special prize for vocational schools for which only two schools are selected across Europe.

The ceremonial delivery of the certificate should take place - as far as possible due to COVID-19 - at a large event in November 2020 in Berlin as part of the so-called “Entrepreneurial Week”.

The teaching faculty and management of the HTL Wolfsberg is convinced that supporting the entrepreneurial skills of its students and participating in entrepreneurial competitions is a strategic, very important basis for ensuring self-esteem, courage and self-confidence as well as the employability of young people. Belief and working on your own ideas are an essential basis for the further development of our society and cannot be encouraged early enough (Fig. 12).

THE ENTREPRENEURIAL SCHOOL AWARDS 2020

HTL WOLFSBERG
innovation alive

Fig. 12. The Entrepreneurial School Award 2020 for the HTL Wolfsberg (Higher College for Engineering Wolfsberg)

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Public-Private Partnership Within the Context of Digital Transformation: Increasingly Larger Role of Educational Institutions

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Abstract. This paper deals with studying the innovative trends in forming the mechanism of public-private partnership (PPP) in education in the Russian Federation, considering global trends. We identified the special aspects of using PPP as a tool in educational activities under certain conditions. We considered various approaches to developing the PPP models and illustrated the relevant mechanism involving a public corporation and an engineering university. Viable models were proposed for the interrelations of businesses, authorities, and educational institutions beyond the known schemes; we also justified their feasibility and showed how PPP activities affect forming the contents of engineering education, enhancing its quality, increasing the qualifications of academic staff, activating academic mobility, and developing international contacts and interuniversity relations.

The authors are proving the necessity of involving the authorities in PPP to support the educational institutions of additional professional education (APE) and solving the strategical problems of developing the real-sector enterprises.

We analyzed the key aspects of PPP in education, exemplified by a specific university. The findings can be widely used to perform applied studies on the relevant topics, while the models developed can be further reproduced.

Keywords: Additional professional education · Public-private partnership · Educational innovations · National projects · Engineering university

1 Context

Like many developed economies, modern Russia experiences the lack of highly qualified engineering workforce, and solving this problem is possible through new approaches to engineering education and enhancing the importance of additional professional education (APE).

In recent years, many social problems are being solved based on national projects and relevant federal programs. A distinctive format of interaction in the context of a public-private partnership (PPP) allows educational institutions to increase the amounts of implementing additional vocational programs and find new customers, while businesses get a unique opportunity of advanced training of personnel, considering the strategy of developing the company at the expense of federal funding of educational

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institutions, in form of grants. This ensures the state focus on developing a comprehensive system of the lifelong education of citizens. This ideology is reflected in the national project titled *Education*.

At the same time, the focus retained on market transformations in education, considering contemporary challenges, such as globalization, digitalization, and past and expected industrial revolutions. New approaches are required to university management, a certain transformation of the mentality of academic society, and search for alternative funding sources. Contemporary market system determines the necessity of the interaction between market operators and the representatives of all types of entrepreneurship, from small to large. Education system reform must be primarily implemented through the partnership of the state and the businesses. To collaborate and cooperate, it is possible to use the PPP mechanism assessed by experts as an education modernization institution in accordance with Federal Law No. 273-FZ dated December 29, 2012: *On Education in the Russian Federation*.

In its *Program of Economic Development for the Period up to 2020*, the Government of the Russian Federation defined a public-private partnership as the main system of developing both the economy in general and, more specifically, education of all levels [1]. Developing the methods of implementing PPP in education is an important condition for achieving the goals of the economic development of the Russian Federation. PPP enhances the interest of educational institutions in the high-quality fulfilment of their functions, strengthens their responsibility against stockholders, and creates favorable conditions for their independent activities in the given circumstances.

Key signs and characteristics that allow distinguishing PPP from other types of interaction between state and business are defined by the Committee for Science and Technology Policy at the Organization for Economic Cooperation and Development (OECD) [2]:

a) Both governmental and private institutions are involved in the partnership;
b) Relationships of the parties are those of equal partners;
c) Relationships of the partnership parties are recorded in official documents, such as contracts, agreements, etc.;
d) Partners have common goals and combine their contributions to achieve them; and
e) Obtaining and using common outcomes are based on sharing by the partners the relevant expenses and risks.

A distinctive feature of PPP is that exactly this type of interactions suggests that the state represented by its authorities does not exercise its authoritative powers, but it acts as a partner in achieving socially important goals together with the business representatives. There are also noted its advantages, such as possibility to accelerate socio-economic development; reducing the expenditures from state budget; reforming the public sector; increasing the amounts of implemented highly-efficient projects; higher-quality selection of projects proposed, considering public needs and involving the managerial experience of the private partner; minimizing risks and obtaining the synergetic effect; enhancing the quality of services.

Synergetic effect of interactions among authorities, public institutions, and private sector enables transferring the project risks upon each partner in it, based on their ability to manage risks; responsibilities are redistributed within the entire lifecycle of the project; and corruption parameters or other illegal practices are weakened.

Through implementing innovative technologies and management methods, PPP creates higher managerial standards, which significantly affects the quality of services provided. At all stages of the PPP project implementation, the rights and obligations of the parties are juridically recorded, which ensures the implementation of projects in compliance with their budgets and schedules.

To correctly use a tool like PPP, it is important to comprehend its mechanism, that is to study the aggregation of all forms and models of its implementation. Experience proves their evolution and diversification, and there have already developed many schemes of successful interaction of businesses with the state [3].

A viable model of interaction among businesses, authorities, and educational institutions is shown in Fig. 1.

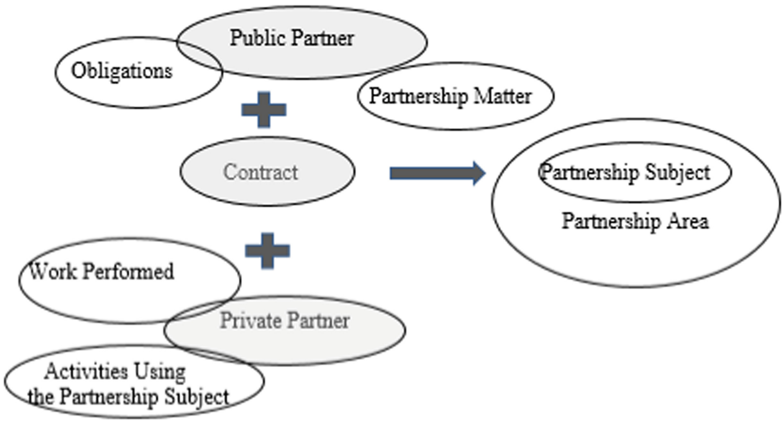

Fig. 1. PPP mechanism in education.

Currently, there is a trend to combine the efforts of state, scientific society, educators, and business society to define the areas of the further development of engineering education. This study presents distinctive PPP models aimed at solving this problem and having been piloted for many years.

2 Purpose

Conventional models are presented as follows (Fig. 2):

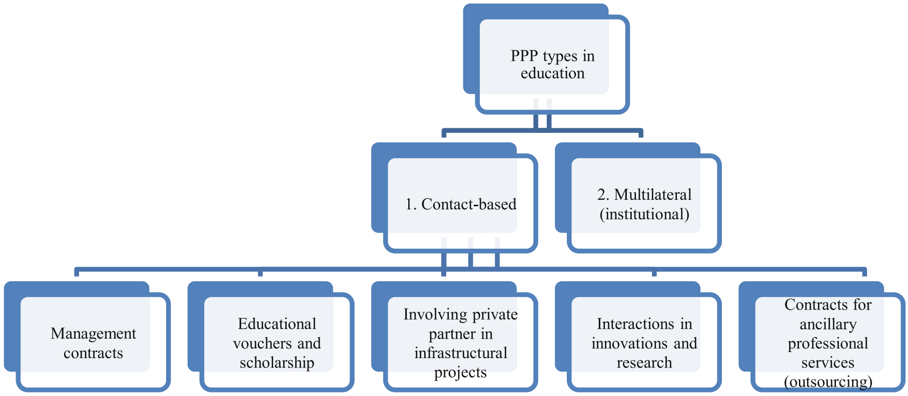

Fig. 2. Classification of PPPs in education abroad

Our study presents the models, in which the state involvement takes rather distinctive forms, while areas of activities of the educational institution, rather than infrastructure, act as the partnership subject. Both models are based on the experience of the largest university of technology in Russia.

The first model is determined by the history of the additional education system in the university and by its subsequent development of additional professional education programs.

Additional professional education (APE) system could only rely on its own resources in the post-Soviet Russia for quite a long time. Such resources were formed either at the expense of vocational education institutions, in which APE departments were established, or at the expense of founders. Since 1990s, the state has only been present on the additional education market as its regulator: It developed the rules and procedures of licensing and accrediting educational activities and performed control and supervision in this area. However, many rules had to be abolished based on the resolutions of the Federal Antimonopoly Service, since private educational institutions following the rules got onto a lack of playing field, as compared to federal and municipal ones.

All attempts of the additional education leaders to initiate state support for the system and adopt a special law came up empty. However, in regions, the situation developed in different ways. New approaches to forming a PPP model in additional education were designed in the Republic of Tatarstan in late 1990s already. Regional authorities supported a federal experiment, and the Republic established an innovative regional APE model based on APE departments and institutions with a single responsibility center based in the Institute of Additional Professional Education (IAPE) of KNRTU. Thereupon, the Institute was accredited by the Ministry of Economy and Industry of the Republic of Tatarstan as a common and state APE authority in implementing additional educational programs. The regional government also adopted some ordinances: On obligatory special training of those applying for managerial positions; on establishing the grants of the Government of the Republic of Tatarstan for training and retraining the personnel residing in the Republic of Tatarstan in Russian and foreign scientific and educational centers; on organizing the training of educators and education coordinators for the APE system, including those teaching at in-house trainings; some enterprises were granted with funds to be allocated for advanced training of their staff in the areas relevant to and demanded for by the Republic. This is how the basics of PPP were developed in the region as a triad: Authorities – educational institutions – corporations/industrial enterprises.

Unfortunately, this practice was not properly further developed. It was argued that the authorities may not force organizational and financial terms and conditions on businesses regarding training and advanced training of their staff. At the same time, the state, at all levels, steered away from solving the difficult problem of developing the social responsibility of businesses represented by new Russian owners. Therefore, educational institutions and APE departments had to build up their relationships to business partners independently, undertaking both instructional and educative mission. Those were them that had to develop in businesses a conscious need for and responsibility for training and advanced training of their staff. However, in this case, any schemes of interaction strongly depend on the economic situation and cannot guarantee any stable demand for and orders for trainings. Only systemic interaction of state, businesses, and educational institutions, i.e., PPP, can be a tower of strength for continuous education as a guarantee of labor and social protection and as an essential condition of economic growth. This mechanism, in turn, determines certain requirements for the system of education and always checks it for being ready for innovations, for quick responses to the needs of consumers, and simultaneously for the observance of strict rules of the game when using budget funds.

In universities, the APE system risks increased due to the growing practices of creating and developing corporate universities in large companies. Corporations consider it to be much more profitable for themselves to keep this money inhouse and to improve personnel training through the in-house training system. In our opinion, however, only institutions of vocational education, primarily universities that have staff, experiences, and necessary teaching aids and scientific support, are able to both train the personnel and provide advanced staff training, and “carry” bachelors to the level required by a specific manufacture. At the same time, really well-established companies, being aware of the relevancy and necessity of investing in personnel development, understand that the advanced training of their staff should be performed involving those who usually trains the personnel for their industry.

In this regard, the PPP model involving the leading petrochemical corporation, PJSC Gazprom, and KNRTU can be considered as one of the most indicative. We characterize this model as a version of PPP because Gazprom is a 100% government-owned corporation. So, the social policy of the company in respect of funding the so-called flagship universities also means the social responsibility of business, stimulated and supported by the government.

The first step in developing the Gazprom-KNRTU PPP can be considered the long-term bilateral agreement executed between the above partners in 2007 to implement the educational project of the Gazprom Corporate Institute – the advanced training program for managers and shift engineers at compressor stations and shops, consisting of four modules of totally 256 academic hours. The program attendees included into the company’s succession pipeline represented the leading gas-transporting affiliates of the company. The first 80-h module was taught based on the Compressor Machines and

Units Department of KNRTU and included lectures and workshops performed at OAO Kazankompressormash and motor-building company by the leading professionals of the companies and of the university. During training, attendees and university faculty exchanged their experiences, which is of special importance. Analyzing manufacturing problems and summarizing best practices allows promptly and considerably correct the traditional, “student-attended” lecture-based courses and the tasks for term projects and graduation projects for the students majoring in Vacuum and Compressor Equipment of Physical Units. All this ensures the practical “rapprochement” of federal state educational standards and employers’ requirements.

The second module of the program consisted in the on-job training at a gas-transmission station equipped with advanced machines and units. Along with the PJSC Gazprom’s professionals, the faculty members of our university are involved in this module, too. The third module dealt with the matters of personnel management and was implemented at the Gazprom Corporate Institute.

Upon completion of each module, interviews and round tables were conducted.

Finally, the fourth module is a 2-week practical training at German enterprises. Both university teaching staff and the program attendees were sent there for practical training. Upon completing the studies, the attendees had an interdisciplinary examination based on the contents of all four modules.

This collaboration resulted to a great extent from the initiative activities of the parties. However, later on, working with Gazprom become for the IAPE one of its priorities with the diversification of working formats. Its contents and dynamics are shown below in Figures and Tables, as well as in many publications [4–6] (Tables 1 and 2) (Figs. 3 and 4).

Table 1. Dynamics in KNRTU involvement in annual PJSC Gazprom tenders

Tendering year	Program implementation year	Number of programs applied	Number of programs won
2015	2016	78	10
2016	2017	106	17
2017	2018	153	35
2018	2019	137	47
2019	**2020**	**178**	**43**

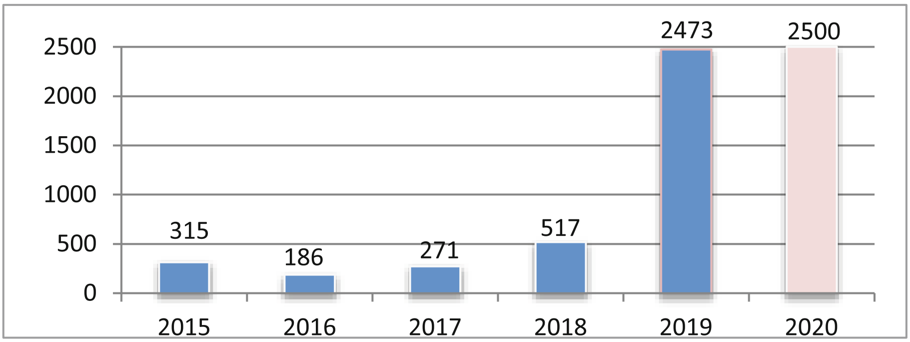

Fig. 3. PJSC Gazprom attendees under APE programs

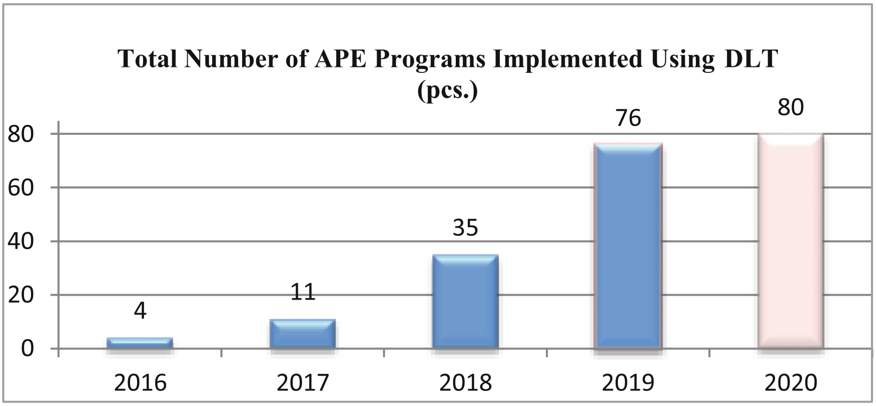

Fig. 4. Total number of APE programs implemented using DLT (pcs.)

Table 2. KNRTU IAPE events under PJSC Gazprom donation agreements

#	Academic year 2015/16	Academic year 2016/17	Academic year 2017/18	Academic year 2018/19	Academic year 2019/20
1	Developing and testing APE programs	Developing APE program materials, using distant learning technology (DLT)	Developing APE program materials, using DLT	Developing APE program materials, using DLT	Developing APE program materials, using DLT
2	–	Equipping a specialized Internet-classroom	Equipping 1) Laboratory of Educational Resources; 2) Psychological trainings	–	Equipping a specialized Internet class for developing and implementing APE programs
3	–	Holding the International Network Conference SYNERGY’2016	Holding the International Network Conference SYNERGY’2017	Holding the International Network Conference SYNERGY’2018	Holding the International Network Conference SYNERGY’2019
4	–	Developmental assignments of the KNRU faculty and management at PJSC Gazprom affiliates	Developmental assignments of the KNRU faculty and management at PJSC Gazprom affiliates **RUB 0.5 million**	–	Developmental assignments of the KNRU faculty and management at PJSC Gazprom affiliates
5	–	–	–	–	Support for the activities of the Tekhnolider (Technoleader) School

The second PPP model results from the subsequent activities aimed at forming partner relationships; it will be presented below.

3 Approach

Kazan National Research Technological University (KNRTU) is characterized by a successive system of developing general, additional, and vocational education, primarily in engineering activities, by a professional society of mentors, and by a many-year practices of involving business structures in developing the professional competences of teaching staff. KNRTU activities are focused on innovative development and on forming the new PPP mechanisms. However, implementing them does not lead to new objects outside, but results in the changing infrastructure of the university; additional opportunities for mobility and publishing activities, including in the scientific journals included in international citation bases; developing a new communicative environment; growing recognition of the capabilities of academic society and therefore, diversifying the areas of partner relationships; etc.

By 2000s, many Russian universities training future engineers have formed new approaches to the contents of engineering education, including thanks to popularization of engineering pedagogy in Russia. Recognizing the importance and significance of professional-pedagogical component of engineering education [8], we can assess engineering pedagogy from an unconventional prospective, having tied it to the teaching function of an engineer at manufacturing, in a company, or in the activities of educational departments of various institutions (today, all this is called in-house training). Based on this concept, we at KNRTU have managed to integrate the general and additional professional education. Moreover, an important component of APE is the Center for Professional Retraining and Advanced Training for University Professors founded in 1994 and functioning up to now based on the IAPE. Its faculty members and programs are funded from state budget. Their active involvement in working with enterprises, as well as the high demand for the programs developed in the Center, such as Pedagogical Skills of In-House Training Teachers, Eloquence Training, Adaptation of Young Professionals, and Mentorship, can also be an example of efficiently using state-provided funds in commercial activities.

In 2008, to enhance the rating, competitiveness and attractiveness of the university on the market of educational services, brining KNRTU into the additional education market, and to ensure the growth of revenues from educational activities under additional education programs, we at KNRTU developed a target program titled *Additional Education as a Factor of the Innovative Development of the University* that allowed strengthening the IAPE positions, extend the range of programs offered, and activate the work of teaching staff. Today, the additional education is considered in the university as an important trend in the activities of departments and faculties, and the indicators of being involved in the APE programs were accounted in the individual ratings of teaching and managing staff.

The APE system of the university is the most open to experiments and integration processes and to testing the relevant forms of interaction of all the interested participants of the process of training and advanced training of professional staff for the contemporary labor market. It is in the APE system where the systemic activities were commenced aimed at developing remote training, thanks to the financial support of PJSC Gazprom.

4 Actual Outcomes

However, in 2019, this system went through very serious facings, in form of a large range of orders for advanced trainings under national projects titled *Education* and *Demography*, which allowed us subsequently to draw a conclusion regarding the actual creation of the second PPP model in additional education.

Thus, under the project titled *Training of Citizens under Continuous Education Programs at Educational Institutions Implementing Additional Educational Programs and Vocational Training Programs* of the federal project titled *New Opportunities for Everyone*, the university had to train 5,000 (!) people under 17 quite specific petrochemical programs using remote training technologies within one and a half months. And first, we had to find such customers among institutions and individuals.

Under the project titled *Training Academic Staff and Employees of Institutions for Implementing the Advanced Remote-Training Programs*, along with training over 1,000 people under 22 programs (also provided that we found our customers independently), we had to publish textbooks and develop the online versions of our courses.

Two other orders based on the federal project titled *Senior Citizens* were also quite challenging for the university either due to the unpreparedness of the attendees for using remote or, in general, information and communication technologies, or due to the needs for specialized equipment for servicing senior citizens.

However, all public orders were fulfilled, and the customers from among our permanent business partners and professional educational society managed to gather the necessary pool of attendees within noticeably short times. Testimonials received by the university proved that all parties obtained the necessary outcomes. The university demonstrated again the efficiency of the existing APE model, having practically doubled the number of attendees, as compared to 2018, without compromising the education quality and with testing both new educational technologies and new PPP models, where the ability to quickly respond to changing environments and rules of the game is more important than the degree of parity.

Tables below present the information on state programs that contribute to developing the continuous education of different categories of citizens and develop the PPP ideas through combining the interests of the state, businesses, and educational institutions in solving important socio-economic problems (Tables 3, 4 and 5).

Table 3. Governmental program titled *Employment Promotion in the Republic of Tatarstan for 2014–2020* (advanced vocational training of those employed by manufacturing companies that restructure and retrofit manufactures in accordance with investment projects)

2014	2015	2016	2017	2018	2019	2020
150	184	176	237	298	458	**470**

Table 4. Regional project titled *Employment Promotion and Enhancing the Efficiency of Labor Market to Ensure Better Performance* in 2018–2024

2018	2019	2020
298	385	**400**

Table 5. National project titled *Labor Performance and Employment Promotion* (Russian Government Ordinance No. 3025-p dated December 30, 2018: On Approval of Special Program and Action Plan to Organize the Vocational Education and Additional Professional Education of Preretirement Citizens for the Period up to 2024)

2019	2020
73	200

5 Summary

Thus, in implementing such PPP models, educational institutions start playing more and more active role. Digital transformation of educational environment sets the new parameters of joint activities for all users of educational services [7, 9]. Due to quick response to the changing conditions of activities, ability to learn, and readiness for using IT in quite different situations, it is with good reason that universities become advocates of advanced ideas and technologies.

Experience of 2019 has shown that, in the context of Russia, the state must remain the indispensable participant of educational activities, including where this is about educating the employees of companies of different types of incorporation and private entrepreneurs. At the same time, without having established stable partner relationships, no measures of state support will work. Obviously, social sector structures shall also be involved in PPPs with educational institutions to implement social and humanities programs. It is reasonable to form governmental orders for such programs and then consecutively implement these ideas within a PPP.

Most typically, socially important institutions and projects act as the elements of PPPs. What is important is that, thanks to PPPs, the time interval decreases between identifying the need and solving the problem. For this reason, PPP may become the most reasonable solution that allows implementing promising projects “here and now” through involving state budgetary funds to solve regional problems as the patterns of financial cooperation. Implementing PPP also allows us to reorient educational institutions for providing high-quality services to individuals and businesses, which allows solving many regional problems and implementing the programs of developing municipalities. In turn, it is possible to implement innovative technologies and advanced management methods in government-owned corporations.

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Research in Engineering Pedagogy

What Drives Sophomore Students to Study Electrical Engineering? The Case of Danish and Israeli Students

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Abstract. Successful implementation of future industrial revolutions requires, inter alia, well-trained engineers. However, the Western world is suffering from an ongoing shortage in engineers. Fostering academic motivation plays a major role in the efforts to reduce dropouts among engineering students. Therefore, the study described here was aimed to map and analyse the motivational factors driving sophomore students at two technical universities, Danish and Israeli, to study electrical engineering. Eighty-nine Danish and Israeli sophomore students participated in the study. The students filled out an anonymous Likert-like questionnaire used to characterise their academic motivation. It was found that there were no significant differences between the two groups of students with regards to the motivational factors. The students at both universities were mostly driven by intrinsic motivation (i.e., interest in studying engineering) and identified regulation (i.e., recognition of the value inherent to these studies).

Keywords: Academic motivation · Sophomore students · Electrical engineering

1 Introduction

"Industry 4.0", the present industrial revolution, is based on Cyber-Physical Systems, Internet of Things and Big Data [1]. Successful implementation of current and future industrial revolutions requires, among other things, well-trained engineers [2]. However, the Western world is suffering from an ongoing shortage in engineers [3, 4]. As a result, many actions are being taken to attract applicants to undergraduate engineering programmes on the one hand [5, 6], and to reduce dropouts among engineering students on the other [7, 8].

Fostering academic motivation plays a major role in these efforts [9–11]. Therefore, the study described here was aimed to map and analyse the motivational factors driving sophomore students at two technical universities, Danish and Israeli, to study electrical engineering. To the best of our knowledge, such comparative analysis was performed here for the first time.

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The chapter opens with a concise theoretical review that classifies the major motivational factors as defined by self-determination theory. The research goal and methodology are then described. A discussion of the findings concludes the chapter.

2 Motivational Factors

One of the common definitions of motivation is the individual's desire to invest time and effort in a particular activity.

Self-determination theory, which is one of the leading motivation theories today, positions the factors driving the individual to take part in a certain activity on a spectrum [12]. This continuum ranges from the extreme of perceived control (coercion), characterised by a low degree of autonomous motivation that does not permit self-actualisation, to the other end of perceived autonomy, which is characterised by a high degree of autonomous motivation allowing self-actualisation [13].

The motivational factor characterised by the highest degree of perceived control is external regulation (Table 1). This factor represents the individual's desire to obtain material compensation for the activity, or, alternatively, a fear of consequences from a failure to complete it.

The next motivational factor with a lower degree of perceived control (and a higher degree of perceived autonomy) compared to external regulation is introjected regulation. This factor expresses the individual's wish to be positively esteemed for completing the activity, or, alternatively, his/her desire to avoid the guilt tied to a failure to finish it.

Moving on the spectrum towards the perceived autonomy extreme, one comes across the next motivational factor, identified regulation. This factor originates from identifying the importance of the activity with regards to the individual's goals or the values he/she holds. It should be noted that self-determination theory views the three motivational factors described above as extrinsic factors.

On the other pole of the continuum is intrinsic motivation, characterised by the highest level of perceived autonomy and stemming from the interest and pleasure the individual finds in the activity.

The individual's level of autonomous motivation is usually measured using the Relative Autonomy Index (RAI) [14]. This indicator is defined as a linear combination of the four motivational factors described above, appropriately weighted. The index assigns higher weight in absolute terms to a motivational factor when it closes to one of the extremes on the spectrum. Additionally, motivational factors characterised by a relatively high degree of perceived autonomy are assigned positive weight, while those characterised by a relatively high degree of perceived control are assigned negative weight. The index is as follows:

$$\mathrm{RAI} = 3S_{\mathrm{Intrinsic}} + S_{\mathrm{Identified}} - S_{\mathrm{Introjected}} - 3S_{\mathrm{External}} \qquad (1)$$

where S_i is the score of motivational factor i, as measured using an appropriate research instrument.

Table 1. Self-determination theory: major motivational factors.

Motivation	Regulation	Origin	Degree of perceived autonomy	Degree of perceived control
Intrinsic		Interest and pleasure the individual finds in the activity	Highest	Lowest
Extrinsic	Identified	Identifying the importance of the activity with regards to the individual's goals or the values he/she holds	High	Low
	Introjected	Individual's wish to be positively esteemed for completing the activity, or, alternatively, his/her desire to avoid the guilt tied to a failure to finish it	Low	High
	External	Individual's desire to obtain material compensation for the activity, or, alternatively, a fear of consequences from a failure to complete it	Lowest	Highest

3 Research Goal and Questions

3.1 Research Goal

The study was aimed to map and analyse the motivational factors driving sophomore students at two technical universities, Danish and Israeli, to study electrical engineering.

3.2 Research Questions

The following research questions were formulated:

- What drives students in their third semester to study electrical engineering?
- Is there a difference between Danish and Israeli students with regards to their motivational factors?

4 Methodology

4.1 Participants

Thirty-eight Danish electrical engineering students (third semester) and fifty-one Israeli electrical engineering students (third semester) took part in the study. The Danish students were from the Technical University of Denmark (DTU). Their three-and-a-half-year programme (BEng) was of a practical orientation and included a six-month internship in industry.

The Israeli students were from the Technion – Israel Institute of Technology (Technion). Their four-year programme (BSc) emphasised profound theoretical and practical training in electrical engineering.

Participants' characteristics were similar to those usually enrolled in these programmes. Table 2 summarises relevant information on the participants.

Table 2. Participants.

University	Country	Programme	Semester	N
DTU	Denmark	BEng	3	38
Technion	Israel	BSc	3	51

4.2 Procedure and Instruments

The participants filled out an anonymous questionnaire used to measure their academic motivation. The questionnaire, based on the Self-Regulation Questionnaire – Academic [15], was a five level Likert-like scale, ranging from "strongly disagree" to "strongly agree". The questionnaire included twenty statements reflecting the four motivational factors described in Sect. 2. Sample statements are provided in Table 3.

Table 3. Questionnaire: sample statements.

Motivation	Regulation	Sample statements
Intrinsic		• I am studying electrical engineering because I think the studies are interesting • I am studying electrical engineering because I think the studies are enjoyable
Extrinsic	Identified	• I am studying electrical engineering because I think working in electrical engineering would be a good job for me • I am studying electrical engineering because I think that by doing so, I am contributing to the improvement of my country's economic situation
	Introjected	• I am studying electrical engineering because I want people to think I am smart • I am studying electrical engineering because my parents want me to do so
	External	• I am studying electrical engineering because I do not have a choice • I am studying electrical engineering because I am supposed to do it

The statements were validated by two experts in engineering education. Cronbach's alphas were within a range of 0.78–0.86 (Table 4), indicating good internal consistency. The data were statistically analysed and the corresponding effect sizes (Cohen's *d*) were calculated.

Table 4. Questionnaire: internal consistency.

Motivation	Regulation	Cronbach's alpha
Intrinsic		0.84
Extrinsic	Identified	0.80
	Introjected	0.78
	External	0.86

5 Findings

First, we present the Relative Autonomy Index as calculated for Danish and Israeli students. Then, the mean score of the four motivational factors among these students is shown. Finally, the motivational factor scores are displayed.

5.1 Relative Autonomy Index

Table 5 presents the Relative Autonomy Index (1) (mean M, ranging from −16 to +16, with standard deviation SD) of Danish and Israeli students. Among both groups, the mean value of the index is slightly under the third quartile. A *t*-test shows that there is no significant difference between the two groups ($p > 0.05$), and the gap between them is characterised by a small effect size ($d = -0.12$).

Table 5. Relative Autonomy Index.

University	M	SD
DTU	7.67	3.89
Technion	7.27	2.97

5.2 Mean Motivational Factor Scores

Figure 1 displays the mean score (ranging between 1 and 5) of the four motivational factors among Danish and Israeli students. In both groups, the intrinsic motivation score is the highest, the identified regulation score is in second place, close to the first and higher than the scores given to introjected regulation and external regulation.

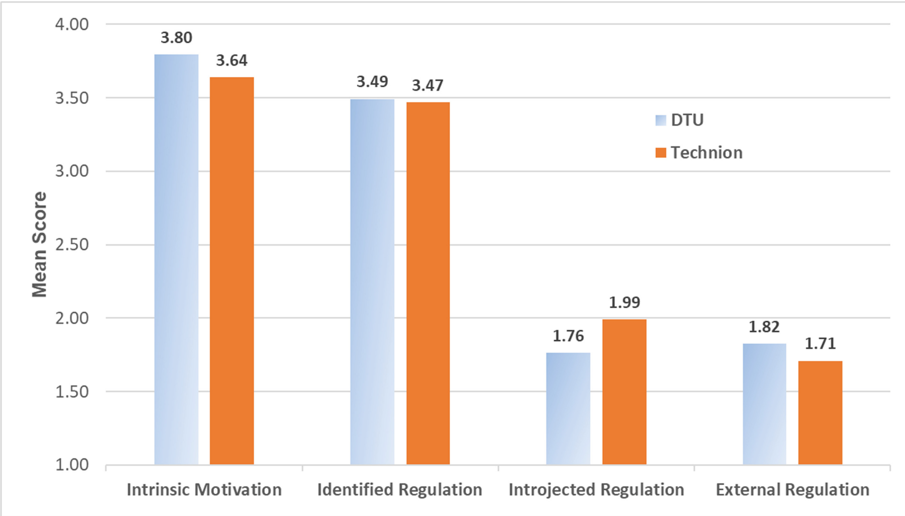

Fig. 1. Mean motivational factor scores.

5.3 Motivational Factor Scores

Table 6 shows the scores assigned to the various factors and the corresponding effect sizes. *t*-tests indicate that there is no significant difference between the two groups in any of the factors ($p > 0.05$). The gaps between the groups are accompanied by small effect sizes.

It should be noted that MANOVA was not performed here since the motivational factors are highly correlated [7].

Table 6. Motivational factor scores.

Motivation	Regulation	University	M	SD	*d*
Intrinsic		DTU	3.80	0.69	−0.23
		Technion	3.64	0.68	
Extrinsic	Identified	DTU	3.49	0.49	−0.04
		Technion	3.47	0.69	
	Introjected	DTU	1.76	0.63	0.33
		Technion	1.99	0.74	
	External	DTU	1.82	0.68	−0.17
		Technion	1.71	0.66	

6 Discussion and Conclusions

It was found that there were no significant differences between Danish and Israeli students with regards to the motivational factors, and that the gaps between the groups were accompanied by small effect sizes. In other words, despite the differences between Danish and Israeli students and their programmes, their motivational factors were very similar. The students were characterised by a relatively high RAI and were mostly driven by intrinsic motivation (i.e., interest in studying engineering) and identified regulation (i.e., recognition of the value inherent to these studies).

The distribution of motivational factors identified by the current study is similar to that of junior electrical engineering students in Israel [16]. However, to the best of our knowledge, such comparative analysis was performed here for the first time.

The research faced two main limitations: (a) a relatively small number of participants, and (b) the fact that only two programmes were studied. However, we believe that even a study with this scope has both theoretical and practical contributions.

The theoretical contribution is in the analysis of the motivation towards electrical engineering studies among second-year students in Denmark and Israel. The study's practical contribution may be reflected in the implementation of its findings in order to reinforce high-quality motivation among beginning students of engineering. These contributions are further validated in light of the vital shortage of engineers [3] and the major role academic motivation fulfils in reducing dropout rates among students [9].

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"Search for Physics Laws"—A New Laboratory Course for Engineering Students

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Abstract. Laboratory course is traditionally one of the most important components of university physics course. It is supposed that after such course students will have basic skills for conducting an experimental research. Unfortunately, the teaching experience and the results of performed tests show that most students do not acquire the necessary skills. In this article we present a new laboratory physics course in which the algorithm of systematic construction of students' skills for carrying out an experimental research is realized. The evaluation of the first part of the course is based on responses to a written questionnaire administered to three groups of students: an experimental group (85 students) and two control groups (61 and 23 students). The results suggest that the new course provides more effective learning the basic skills of error analysis.

Keywords: Systematic construction of mental actions · Laboratory course · Analysis of experimental data · Physics law

1 Introduction

Laboratory course is traditionally one of the most important components of university physics course, and it is expected that as a result of this activity students learn how to appropriately interpret obtained experimental data. Unfortunately, we have revealed that a lot of our students had marked difficulties in understanding even the basic ideas of error analysis.

The literature analysis showed that concerns about the current state of students' knowledge after traditional laboratory course of physics are not uncommon. It was noted in [6] that 'professors of all levels admit to being frustrated at students' lack of ability and understanding in these areas'. Authors of [5] established that often students 'perform lab experiments in a plug-and-chug frame, procedurally completing each activity with little to no sensemaking'.

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2 Literature Review

There are several researches which point out ways of changing the situation. The negative but important result about effectiveness of a traditional physics laboratory course was described in [4]. The author compiled a list of topics that experts believe students should know and checked if students really have this knowledge. The biggest amount of data was gathered at two universities and it was expected that students from the first sample should demonstrate a better understanding of measurement uncertainty than students from the second sample, because the topic of error analysis is emphasized much more in the first university physics labs. However, the study revealed that students from both university "have difficulties with many of the fundamental aspects related to measurements and the comparison of measured values" [4].

A study about improving students' understanding of measurement and uncertainty in the physics laboratory was presented in [5]. A whole introductory algebra-based physics course (lectures, homework assignments, discussion sections) was considerably modified for this purpose, and the traditional introductory lab was replaced by scientific community laboratory, where students were given only a paragraph describing the research question and had to work in groups of four designing and carrying out an experiment to answer that question. At the end of lab each group presented their method, data, and analysis to the rest of the class, trying to convince the other students of their conclusion. The author argues that after this course students leave lab with an understanding of the basic concepts underlying uncertainty analysis and are ready to learn the mathematical tools of uncertainty analysis in the second semester of physics course. Also, reassuring results was obtained by [8] in a school laboratory. The author asserts that students' inadequate views of experimental work in science could be changed in relatively short time.

As regards a cause of students' misconceptions and misunderstandings of error analysis, according to authors of [3], it is using *point paradigm* instead of *set paradigm*. About designing a special course and a set of materials based on the probabilistic framework for measurement was reported in [7]. The course has been evaluated, and the authors claim that the new course considerably improves students' understanding of uncertainty.

We share the authors [7] view on importance of using the set paradigm, however, experience prompts us an additional cause of students' failure in gaining skills for analyzing obtained experimental data—their unpreparedness for such activities.

3 Idea About Systematic Construction of Mental Actions

Traditionally, it is implied that for leaning basic skills for error analysis students just need to conform to well-defined instructions, i.e. self-dependent learning is expected from students. We believe it is quite possible that if physics laboratory course has four hours per week and the course lasts at least three semesters the best students acquire all required knowledge and skills. However, a common laboratory course for engineering majors at our university is much shorter, and we came to a conclusion that usually necessary skills do not develop as expected, and are fragmentary and unstable.

This situation can be changed by replacing 'hope for self-dependent learning' principle with 'systematic construction of skills' principle. This does not mean that we cast doubt on importance of self-dependent learning but, as it will be shown below, students definitely need more help in studying error analysis.

We have used Gal'perin's stepwise approach (see, for instance, [1]) as a working model for outlining the teaching-learning process, and designed an innovative laboratory physics course based on the theory of the gradual formation of mental actions. The main teaching goals of our course "Search for physics laws" are:

1) to build a set of basic skills for conducting an experimental research;
2) to form the idea that the main result of a laboratory work should be finding a physics law.

The first goal is one of the traditional goals of the physics laboratory course. The new thing is that we have abandoned the idea that these skills will be formed spontaneously and have taken the idea of their special purposeful formation. For achieving this goal the whole student activity of carrying out a laboratory work was decomposed into separated elementary skills each of those got its own name. During sessions we described each skill, explained its content, and taught students to fulfill it. Next time we tested their ability to use the skills, and made some final corrections.

We consider the second goal as more important. In our opinion, the fundamental transition from metrology to physics itself has to take place in a laboratory physics course. The basic concept of the course is the concept of 'experimental physics law', and the main tool is a linear function. All processing of experimental data is based on the same scheme as working with parameters of a linear function.

4 Graphical Method as the Thread of the Course

The basic method we teach students is the graphical method of error analysis. It goes through all sessions, starting with the first one (measuring a physics quantity) and ending with the last one (separation of trends and dependencies). This method could give students an intuitive understanding of an experimental situation and the ability to read graphical information.

In addition, using the method let us link together two procedures of error analysis. Instructions for treatment experimental data after measuring some constant physics quantity are essentially different from instructions for analyzing relationships between physics quantities. The way we teach students to use the graphical method for analyzing different types of linear relationship between variables is shown on Fig. 1.

Certainly, the graphical method is just an illustration of the analytical methods of processing experimental data. However, learning the methods of mathematical statistics in depth is premature in the introductory course. Even the level of such special guides as [2] is too high at this stage of studying process. We suggest that it is reasonable to acquaint students with some formulas, and offer them to use these formulas and compare results at the end of each session.

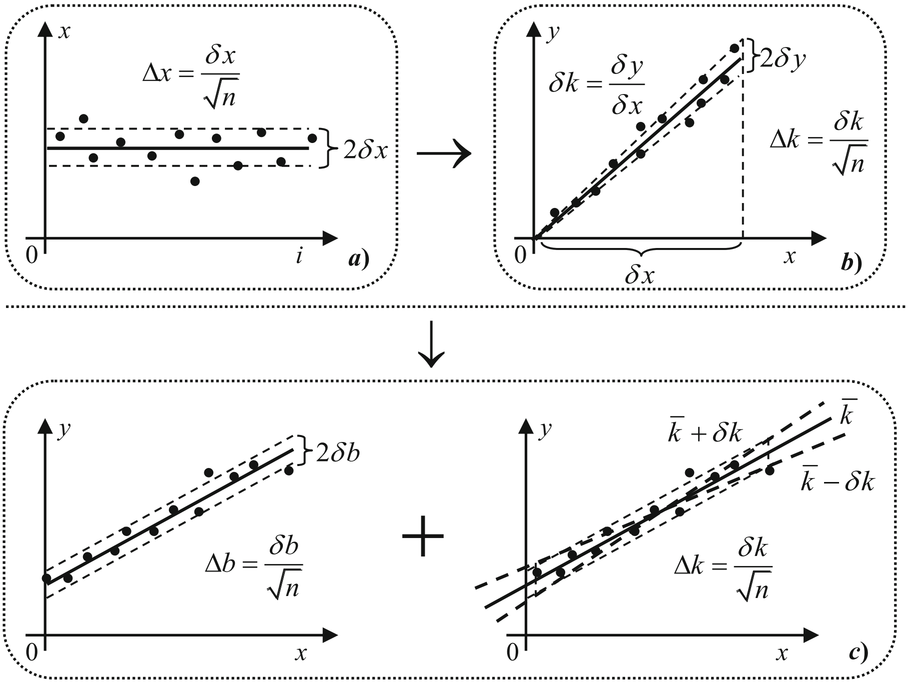

Fig. 1. Scheme of studying the graphical method of error analysis for linear relationships between physics quantities: ***a***) treatment of experimental results after measuring a constant physics quantity; ***b***) analyzing relationships between two physics quantities in a case when the line should go through the origin due to known scientific constraints; ***c***) processing experimental data in a general case of linear relationship

5 Course Description

Our new course “Search for physics laws”, as well as a traditional laboratory physics course, consists of one 2 h session per week for 14 weeks spanning the entire semester. It contains six topics with two laboratory works each and two control sessions. A list of the topics is shown below.

TOPIC 1. FOUR AXIOMS OF PHYSICS MEASUREMENTS

Session 1. Concept of a confidence interval. Laboratory work 1 “Buffon – de Morgan experiment”.

Session 2. Beginning of graphical method. Laboratory work 2 “Measurement of time”.

TOPIC 2. LINEAR FUNCTION

Session 3. First acquaintance with a linear relationship. Building a linear function in the laboratory work 3 “Measurement of the age of the Universe”.

Session 4. How not to get lost in symbols. Self-dependant building a linear function in the laboratory work 4 “Measurement of the liquid viscosity by Stokes method”.

TOPIC 3. LINEAR FUNCTION AS AN OBJECT OF MEASUREMENT

Session 5. Building a confidence interval for y-intercept of a linear function. Fulfilling this operation in the laboratory work 5 "Measurement of the mass of a 'black' load".

Session 6. Building a confidence interval for a slope of a linear function and for an indirect measured quantity. Laboratory work 6 "Hook's law. Measurement of the Young's modulus".

TOPIC 4. POWER FUNCTION

Session 7. 'Straitening' power functions. Fulfilling this operation in the laboratory work 7 "Stefan – Boltzmann law".

Session 8. Dimensional analysis. Power straitening coordinates. Laboratory work 8 "Simple pendulum".

TOPIC 5. STRAITENING COORDINATES

Session 9. Building straitening coordinates in a general case. Laboratory work 9 "Measurement of the lifetime of an incandescent lamp".

Session 10. Experimental proof of hypothesis. Laboratory work 10 "Temperature dependence of semiconductor resistivity".

TOPIC 6. THE BASIS OF DATA MINING

Session 11. The basic concepts of intelligent search in databases: trends and physical laws. Laboratory work 11 "Dulong–Petit law".

Session 12. Interpretation of experimental patterns. Laboratory work 12 "Electrostatic field simulation by using a conductive paper".

TOPIC 7. CONTROL SESSIONS

Control session 1. The theoretical minimum.

Control session 2. Search for physics laws.

As can be seen from the list, the presentation of the material is unhurried, with a gradual complication (see Fig. 2).

At the beginning of the course, we consider the simplest data sets (a degenerate case, a directly proportional function, a general case of a linear function). In the second part of the course, a linear function applies to the processing of more complex sets of experimental data (power functions, functions in a general form).

Note, that the main difference between the new course and the traditional laboratory physics course in National University «Zaporizhzhia Polytechnic» is that in the new course we use another teaching ideas and methods. In the traditional course it is expected that students use instructions and perform all experiments in a 'plug-and-chug frame'.

It is also important, that the new course can be put into practice by using different laboratory equipment.

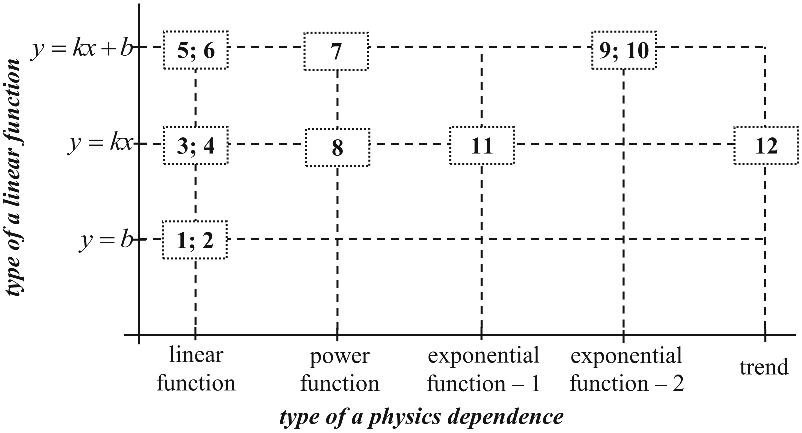

Fig. 2. Structure of the course (1, …, 12 are numbers of laboratory works, "exponential function – 1" is $y(t) = y_0 e^{-\alpha t}$, "exponential function – 2" is $y(T) = Ae^{\beta/T}$)

6 Evaluation of the First Part of the New Course

6.1 Methodology

The evaluative data came from responses of 85 students to written questionnaire after a first semester of our new physics laboratory course over 2017. These students were present at first six laboratory sessions and had an opportunity to learn the first three topics. There were two control groups: a cohort of 61 students after a first semester of a traditional laboratory course was used as a first control group, 23 students which had not yet studied any university physics course formed a second control group. All these students were first-year undergraduate students followed 4 year BSc programmes in Engineering at the National University «Zaporizhzhia Polytechnic» but could have a different background: some of them were graduated from a high-school, the other enter the university after some technical college. Table 1 represents the number of such students in the experimental and control groups.

Calculation a chi-square statistic by using information about students' External Independent Evaluation scores and college final scores showed that the experimental and both control groups had similar admissions standards.

Note also, that students from our experimental group used the same devices and instruments as students from the first group. And students from both groups conducted experiments in small teams (3–4 students) over a course of the entire semester.

The questionnaire was composed of six tasks five of which are related to the first part of the new course and will be reported in this study. Each task targets a particular elementary skill. The student was required to fill in omitted numerical answers, and had 15 min to complete all tasks. The questionnaire was answered individually and under examination conditions, it had originally been given in Ukrainian but the questions had been translated here.

Table 1. Student background of the experimental and control groups

	Graduated from a high-school (%)	Graduated from a college (%)
Experimental group (after the new course, $n = 85$)	55 (65)	30 (35)
Control group 1 (after a traditional course, $n = 61$)	20 (33)	41 (67)
Control group 2 (no university physics course, $n = 23$)	13 (57)	10 (43)

6.2 Findings in Details

The first task of the questionnaire asks students to rewrite an interval of some experimental data.

Question 1. *A student obtained an interval for coordinates of an object at the same instant: from* 24.3 cm *to* 24.9 cm. *Rewrite this result in the form* $\bar{x} \pm \Delta x$.
Answer: $x =$ _____ ± ______ (cm).

For this question, the majority of students from the experimental group gave the right answer (see Table 2). Approximately half of students after a traditional course (control group 2) and one third of students from the control group 3 answered correctly.

The second and third questions refer to the connection between the mean, the absolute and the fractional uncertainties.

Question 2. *Find the fractional uncertainty in the following experimental result:* 64 ± 16 (μC).
Answer: _____%

Table 2. Students' results of Question 1

	Correct value of the mean (%)	Correct value of the uncertainty (%)
Experimental group (after the new course, $n = 85$)	71 (84)	61 (72)
Control group 1 (after a traditional course, $n = 61$)	40 (66)	27 (44)
Control group 2 (no university physics course, $n = 23$)	9 (39)	6 (26)

Question 3. *Find the absolute uncertainty in the following experimental result:* 15 cm ± 20%.
Answer: 15 ± ____ (cm).

These questions had the greatest number of correct responses among the first control group (see Table 3). The experimental group had slightly lower results, and, as expected, the second control group obtained marked lower number of right answers.

Table 3. Students' results of Questions 2 and 3

	Correct value of the fractional uncertainty (%)	Correct value of the absolute uncertainty (%)
Experimental group (after the new course, $n = 85$)	65 (76)	64 (75)
Control group 1 (after a traditional course, $n = 61$)	47 (77)	50 (82)
Control group 2 (no university physics course, $n = 23$)	12 (52)	15 (65)

The fourth task asks students to rewrite a result in the appropriate form:

Question 4. *Round the following experimental result: height* $= 1,6432 \pm 0,237$ (m).

Answer: _______ ± ______ (m).

For this question, the difference between the experimental group and the control groups was appreciable (see Table 4).

The last question required to estimate uncertainties in repeatable measurements.

Question 5. *A student measured some quantity three times, and obtained the following values:* $x_1 = 24, \quad x_2 = 24, \quad x_3 = 21$. *Write down the experimental result in the form* $\bar{x} \pm \Delta x$.

Answer: $x =$ _____ ± ______.

Note, that the formula $\Delta x = \sqrt{\frac{1}{n(n-1)} \sum_{i=1}^{n} (x_i - \bar{x})^2}$ was given.

Table 4. Students' results of Question 4

	Correct value of the mean (%)	Correct value of the uncertainty (%)
Experimental group (after the new course, $n = 85$)	49 (58)	64 (75)
Control group 1 (after a traditional course, $n = 61$)	21 (34)	27 (44)
Control group 2 (no university physics course, $n = 23$)	7 (30)	9 (39)

Despite a hint (the formula for Δx) this question turned out the most difficult for all students (see Table 5).

Table 5. Students' results of Question 5

	Correct value of the mean (%)	Correct value of the uncertainty (%)
Experimental group (after the new course, $n = 85$)	53 (62)	35 (41)
Control group 1 (after a traditional course, $n = 61$)	32 (52)	15 (25)
Control group 2 (no university physics course, $n = 23$)	7 (30)	3 (13)

For comparison the experimental and control groups we combine students' answers to all five questions by assigning 1 point for a right answer, and 0 points for a wrong answer. Thus, students who answered all questions correctly would receive a score of 8 points. The number of students received scores from 6 to 8 in the experimental group was 47 or 55%, in the first control group—14 or 23%, in the second control group—5 or 22%.

7 Conclusion

We have described the new physics laboratory course "Search for physics laws" that is based on the idea about systematic formation of mental actions. This approach offers to use Galperin's stepwise teaching procedure which was developed on the assumption that learning any kind of knowledge is mastery of different kinds of actions [1]. In accordance with this idea, elementary activities required for carrying out a laboratory work were taught separately. Another idea running all through the course is using graphical method for error analysis.

The first part of the course has been evaluated by exploring students' responses to the five questions that required using connection between the mean, the absolute and the fractional uncertainties, estimating uncertainties in repeatable measurements, and rewriting an experimental result in the appropriate form. The evidence strongly suggests that the organized in the new way laboratory sessions has been significantly more successful in improving students' basic skills of error analysis than a traditional laboratory sessions. Our findings about the control group are consistent with research [4] which shows that students have a lot of difficulties carrying out error analysis after a traditional physics laboratory course.

However, we have to admit that the results presented in this work leave a lot of space for further researches. For example, one of the limitations of this study is reflected in the fact that the majority of students in the experimental group was graduated from a high-school but the majority of students in the control group 1—from a college. Additionally, it would be interesting to design an experiment with the purpose of investigating in details the process of students' understanding the basic concepts of error analysis over the whole course.

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Reading Comprehension and Context of the Digital Generation of Secondary Engineering Schools' Pupils in the Czech Republic

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Abstract. Reading comprehension and reading context are in mutual interaction and influenced by several factors, particularly the level of reading literacy and the level of individuals' reading strategies. Reading is part of communication applying the correct (de) coding of written information. An important factor in understanding the information is the set of knowledge and skills elements of a sociological, psychological, ethical and media nature. Language as a tool for the transmission of information and human thinking concurrently reflects the values of the individual and society. This study aims to characterise the level of reading strategies of secondary vocational school students in the Moravian-Silesian Region in connection with the findings of an international survey of reading literacy of 15-year-old students (PISA 2018), which pointed out that Czech students (especially boys) achieve a below-average level in analysed reading strategies. Fifteen-year-old pupils of the region are among the worst regional groups in the Czech Republic. The second goal of the research was to find out which factors influence the development of pupils' reading literacy, during and after working with the (e)text, reading comprehension and the effectiveness of reading comfort. An analysis of the responses of 488 students of three secondary schools of engineering showed that students who read for knowledge prefer a particular topic when reading and that students who ask questions while reading or after reading a text also look for new information to discover a context of information. Another important finding was that reading comfort and reading context are in mutual interaction. To develop an individual's language culture, it is significant to support reading not only as a part of school duties but as an integral part of everyday life.

Keywords: Pupils' reading literacy · Reading context · Digital generation of pupils · Types of texts · Reading comprehension

1 Introduction

The reading context is developed by a diverse range of factors in interaction with the individual's level of literacy and reading strategies. However, the use of transmitted code is essential for understanding the text. The comprehension is influenced by the

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range of knowledge-based elements of sociological, psychological, ethical, media and general nature. Language is inextricably linked to human thinking and reflects the values of the individual and society. The implementation of the constructivist concept of teaching in the Czech Republic lags behind the development in European and other developed countries, which may be the cause of the decrease in the reading literacy of the current digital generation, including students of technical schools. Tompkins (2006), Sandberg and Norling (2020), Oakhill et al. (2014), Stuart and Stainthorp (2015), Hejsek (2015), Vicherková (2017, 2018). Several findings have been provided by international literacy surveys (PISA 2009, 2018) or Whitcroft (2018).

Applying the correct code in the text decoding as a condition for understanding requires not only language skills, communication and reading strategies, skills, competencies, but also the ability to use a range of knowledge-based elements based on a general overview and current context. A language is a crucial tool for creating and fixing personal values. The language sign is a stimulus to the thought process and the formation of connections between concepts and acoustic images. "Reading behaviour reflects the individual's attitude to reading and written culture in general" (Najvarová 2008, p. 46). The first aim of the study is to characterise the level of reading strategies of in the Moravian-Silesian Region in connection with the findings of international literacy survey of 15-year-old students (PISA 2009, 2018) since Czech students (especially boys) achieve below-average levels in reading literacy. The second goal is to name factors influencing the development of reading literacy among Czech pupils of secondary vocational technical schools.

2 Key Factors in Literacy Development

Elements of cold communication manifest in today's communication at school and the family. Rhetorical "beauty" disappears from family communication, the devaluation of messages in journalistic and artistic literary expression is escalating. The haste of passing on information points to the fact that in a regular expression, we prefer factual argumentation, speak in abbreviations, minimise utterances. Podgórecki (1999) points to a caution in the current trend of communication and reminds that "too ascetic form causes certain ossified, or scholastic language patterns, which frequently contribute to the "immobilisation" of content" (p. 78). Communication without personal interest is also reflected in reading. The emphasis on the semantic accuracy of the text disappears from the process of reading. Four fundamental factors in the development of reading were considered for the study: the language function, the role of text in education, the author's communication intention, the text reception.

2.1 Language Function

Certain language functions apply to each speech act. Jakobson (1960) classified the functions of language into six intertwining categories (cognitive, poetic, emotional, conative, factual, metalanguage). People use symbolic signs reflecting the level of thinking of the participants in the communication. According to Doroszewski (1962, p. 67), "language reflects and interprets reality. Reflecting reality, as well as its interpretation, is one of the cognitive and social functions of language because thinking is a social process." In the text work, we also recognise a certain level of reading literacy and reading strategies in the reader. The degree of understanding is also a manifestation of the individual's thinking. According to Podgórecký (1999, p. 171), it is the manifestation of the learners' thinking that "communicative competence indicates the ability to communicate through language". Reading strategies and reading skills are part of reading competencies, classified as components of communicative competencies. "The level of communication competence can be one of the sources of predicting a pupil's success in school" (ibid., P. 176). Communicating effectively and functionally correct is also a prerequisite for success in everyday reality.

2.2 Text in Education

In school education, it is possible to encounter scholarly, but also other types of non-artistic or artistic texts. Apart from teaching the mother tongue, insufficient work is done with structured, journalistic, administrative texts and texts of a plain communication style. In literary education, students learn to understand artistic texts; reading is performed through work with excerpts of texts in reading-books rather than with texts of authentic authorial work. Paper text predominates, electronic forms occur in the form of specialised texts placed on school websites. At present (in March 2020), in connection with the COVID-19 pandemic, elements of inequality in education have emerged in the Czech Republic with the introduction of compulsory distance learning. Socially weaker families do not have technological equipment required for digital communication with schools.

Moreover, parents of children from socially disadvantaged backgrounds do not have enough education and a suitable level of professional and technical knowledge and skills to operate current information resources. Some teachers also experienced problems with electronic communication with students. Although it is clear from the results of the international reading literacy survey (PISA 2018) that Czech pupils have improved in the overall level of written information comprehension, compared to the results of the same international reading literacy survey (PISA 2009), there is a growing national need to develop reading comprehension in all age categories through lifelong learning. Fifteen-year-old Czech boys repeatedly remain on the border of average and below average in comparison with the international group of pupils. It creates a legitimate interest in examining the factors influencing the level of understanding of written information in secondary school students. Students' experience with different types of texts in home, school and out-of-school environments encourages the need to lead students to acquire the skills to understand the information correctly in terms of content and form. It is also desirable to pay attention to non-text components affecting the quality of the information acquisition. It is necessary to strive for the enrichment of their cognitive area, development of emotions, attitudes, behaviours and the cultivation of interpersonal relationships.

2.3 Author's Communicative Intention

The communicative intention, text cohesion and coherence form the basic properties of a comprehensible functional text. In today's educational reality, there is a growing trend that students encounter not only traditional textbook texts, but also complex, both artificial and authentic, texts. Students also gain reading experience in working with encyclopaedic texts, tables, visualisations of information, e.g. graphs or maps. There are many authorial approaches in the classification of texts according to their didactic functions. The emphasis is laid on enriching teaching with experience from everyday texts. Educationally oriented information and everyday life correctly creates an inseparable pair. The educational reading experience should be based on the traditions, goals, needs and requirements arising from life in the society of the 21^{st} century as well as the prognoses of the life of the coming generations. The student of the contemporary school should understand the essence of the explanatory text, the text containing organisational information, the illustrative text, the text with different fonts and the supplementary text.

2.4 Text Reception

The text reception can be understood as receiving and processing information from the text by implementing a three-phase model: perception, understanding, memorisation. According to Gavora (1992), the problem of the text understanding can be perceived as a psycholinguistic activity in which the phenomena of objective reality relate to the elements of the text that denote the given phenomena. It includes the importance of connecting words, sentences, supra-sentential forms and the connection of text elements with several parts of the recipient's knowledge structure. In educational practice, it is necessary to strengthen the complex of analytical and synthetic activities at work at different levels of the text. The research focuses on the student's reading strategies, i.e. how the student analyses the text and sorts the information, how can they reduce the text, etc. Following the International Reading Literacy Research (PISA) we are interested in three processes employed during the work with text for Czech pupils of secondary vocational schools of engineering, namely: information retrieval, information processing, information evaluation. Vicherková (2017, p. 61) in agreement with Hnilica (1992) emphasises the importance of "the work of two-dimensional representation of relations among key concepts in the stage of text summarisation". Knowledge, skills, communication and other key competencies, reading experience, reading strategies, critical thinking, stimulating reading climate, assertiveness contribute to increasing the quality of text comprehension.

3 Researches on Teaching Strategies for Reading Comprehension

Hinchman's (1987) research of the strategies used by teachers in teaching focused on the social side of textbook use, confirmed that the use of textbooks by the three teachers differed significantly. Teachers used textbooks as a primary source of information as well as a complementary or activating teaching resource. The author classified the use of textbooks into three categories. Peacock and Cates (2000) found out that beginning teachers did not make adequate use of all textbook authors' recommendations for exposure, fixation, and application of science to students. The author's intention and potential of the teaching source were not presented in satisfactory quality and quantity. In line with Procházková's (2006) opinion, it can be argued that the Reading Literacy and Project Teaching web portal presents interesting ideas for the development of pupils' reading strategies based on educational practice. According to Průcha et al. (2009), the internal factors of literacy are directly related to the innate dispositions, signs, peculiarities of the individual's nervous system, their personality potential, manifestations and experiences gained throughout the development of humankind. "Objective factors of literacy include those that emerge in an actor's form from the social, cultural and economic context, i.e. from the environment of education in the family, school, but also from the social context" (Vicherková, 2017, p. 51). Working with textbooks and contact with different types of texts also belong to the external factors influencing the level of students' and learners' reading strategies across age. The key to the development of reading strategies is "regular, thought-rich interaction and activating work with the text in school teaching, in the home and out-of-school environment" (Vicherková, 2017, p. 54).

4 Research

A questionnaire survey on a group of pupils from three secondary schools studying engineering in the Moravian-Silesian Region of the Czech Republic was carried out from September 2019 to January 2020. Data were obtained from 488 respondents, mostly boys (467, 95.7% of the total number of students in the 1st to 4th year of engineering studies). The structured questionnaire contained 21 items focused on reading literacy and reading strategies in the teaching of engineering subjects and on students' motivation to study at this type of school. Items providing the possibility to find out whether the differences in the above variables were caused by the differences between paper form or in digital form were selected for the analysis.

Test tasks designed by students themselves, e.g. tasks to find relationships in the image (e.g. gear and hoist), multiple-choice tasks, tasks based on interactive video recordings, quiz sets, tasks with one correct answer to questions about the vocational text of an engineering company, Speak the Words Set, tasks based on summarising, tasks on a timeline for recording chronologically divided events (e.g. description on how to build a closet), working with aphorisms and creating a newspaper headline, identifying the meaning of a message, finding relationships in a text, tasks for a final recapitulation of communication, working with error, jigsaw puzzle, pair reading with reporter and interrogator roles, organising tasks and also selected methods of critical thinking (e.g. five-leaf clover, bingo, diamond, true/false, save the last word for me, etc.) are included among the research methods that contributed to the evaluation of the concept of "understanding" the text.

4.1 Research Aims

The first aim of the research was to characterise the level of reading strategies of pupils of secondary vocational mechanical schools in the Moravian-Silesian Region and to name the factors influencing their development. The second objective was to identify the priorities of selecting topics in reading for cognition, types of reading strategies and activities with an impact on the quality of text comprehension, pupils' motives developing thinking about a technical problem and ways of acquiring knowledge by reading for cognition.

The research problem was decomposed into the following research questions:

1. Do students prefer a particular topic for (e)reading?
2. Is there a connection between the student asking questions during reading and after reading the text and the student's search for context about the information from the text?
3. To what extent does the teaching of vocational subjects encourages thinking about a technical problem towards the search for context about the information from the text (also in connection with the digital context) influence pupils?
4. Is there a connection between the student's acquisition of knowledge from vocational subjects in the form of self-study and their ability to create their own structure of the text(s)?
5. To what extent does the ownership of a home library affect the pupil's preference for reading?
6. Is there a connection between the pupil's reading and their assessment of the importance of working with the text for everyday experience?

Orientation in the issue, research goals and research questions led to the formulation of a total of six research hypotheses, which are presented simultaneously with the results of their statistical verification in the next chapter.

4.2 Descriptive Research Data

Descriptive data further characterise the reading status of individuals in the research sample. The survey in the field of expressing a personal relationship to books and reading showed that 272 (i.e. 56%) respondents read for knowledge, 270 (i.e. 55%) respondents read more than three books in the previous calendar year, 127 (i.e. 26%) discusses the read text(s) with another person at school, at home. In the field of reading procedures, reading strategies) it was found that 196 (i.e. 40%) respondents require a teacher's interpretation to understand the text, 360 (i.e. 74%) pupils prefer a particular topic when reading the text, 134 (i.e. 27%) of the respondents create auxiliary questions during (e)reading, or after reading the (e)text, 310 (i.e. 64%) pupils look for connections about the read information. As for the third research area concerning reading at school, 266 (i.e. 54%) respondents read books only from school duties, and 307 (i.e. 63%) pupils read and analyse a text only in their mother tongue.

4.3 Relational Research Results

Six hypotheses were verified using Pearson's chi-square. The source data and the corresponding statistical results are given in the following tables.

Pupils answered question A2 (reading for knowledge) and question B2 (preference of certain topic) in the questionnaire.

Table 1. H1 hypothesis testing result (contingency table)

Pearson's chi-squared = 7,707798 degree of freedom = 1 significance p = 0,005498			
Question A2/B2	Yes	No	Line totals
Yes	172 (158,61)	43 (56,39)	215
No	188 (201,39)	85 (71,61)	273
Column totals	360	128	488

QA2 – reading for knowledge, QB2 – preference of a certain topic.

Hypothesis H1 stating that students who read for knowledge prefer the topic more frequently than students who do not read for knowledge has been verified (Table 1). There is a statistically significant relationship between the cognitive purpose of reading and pupils' preference of the topic of reading.

Pupils answered the question B5 in the questionnaire (ancillary questions while reading and after reading) and the question B6 (searching for context of the information).

Table 2. H2 hypothesis testing result (contingency table)

Pearson's chi-squared = 4,078670 degree of freedom = 1 significance p = 0,043428			
Question B5/B6	Yes	No	Line totals
Yes	126 (115,61)	56 (66,39)	182
No	184 (194,39)	122 (111,61)	306
Column totals	310	178	488

QB5 – asking ancillary questions while reading and after reading the text, QB6 – looking for context of the information.

Hypothesis H2 stating that pupils who ask ancillary questions, look for the context of the information more frequently than pupils who ask helpful questions, has been verified (Table 2). A significant relationship was found between the parallel cognitive activities accompanying reading and the search for thematically related information.

Pupils answered question C5 in the questionnaire (whether they are helped by teaching activities to understand and memorise the text) and question C4 (consideration of working with text at school to be important for their everyday experience).

Table 3. H3 hypothesis testing result (contingency table)

Pearson's chi-squared = 33,25578 degree of freedom = 1 significance p = 8,07992E-09			
Question C5/C4	Yes	No	Line totals
Yes	167 (137,05)	153 (182,95)	320
No	42 (71,95)	126 (96,05)	168
Column totals	209	279	488

QC5 – helped by teaching activities to understand and memorise the text, QC4 –vworking with text at school to be important for everyday experience.

Hypothesis H3 stating that students whom teaching activities help to understand and remember the text, consider working with the text as important for everyday experience more frequently than students who are not helped by teaching activities to understand and remember the text has been verified (Table 3). The implementation of auxiliary activities to understand the text is thus related to the pupils' perception of the importance of working with the text at school.

Pupils answered question B4 in the questionnaire (creating the structure of the text) and question B5 (ancillary questions while reading and after reading).

Table 4. H4 hypothesis testing result (contingency table)

Pearson's chi-squared = 2,83272 degree of freedom = 1 significance p = 0,092362			
Question B4/B5	Yes	No	Line totals
Yes	58 (49,98)	76 (84,02)	134
No	124 (132,02)	230 (221,98)	354
Column totals	182	306	488

QB4 – creating the structure of the text, QB5 – asking ancillary questions while reading or after reading the text.

Hypothesis H4 stating that "students who create the structure of the text ask ancillary questions more frequently while reading or after reading the text than students who do not create the structure of the text" has not been verified (Table 4). No connection was found between structuring the text and asking ancillary questions in the perception of the text. This somewhat surprising finding will require further analysis.

Pupils answered question Q27 in the questionnaire (vocational subject teacher' guidance to think about a technical problem) and question B6 (looking for the context of the information).

Table 5. H5 hypothesis testing result (contingency table)

Pearson's chi-squared = 0,086666 degree of freedom = 1 significance p = 0,768459			
Question 27/B6	Yes	No	Line totals
Yes	249 (247,75)	141 (142,25)	390
No	61 (62,25)	37 (35,75)	98
Column totals	310	178	488

Q27 – teachers' guidance to think about the technical problem, QB6 – looking for context of the information.

Hypothesis H5 stating that "pupils who have stated that vocational teachers guide them to think about a technical problem seek connections about the information more frequently than pupils who have stated that vocational teachers do not guide them to think about a technical problem" has not been verified (Table 5). It would mean that teachers are not the factor that triggers students' curiosity and subsequent search for the context of the information. It may be the content of the text itself or other individual factors, including the pupil's internal motivation and interest in the subject or field of study.

Pupils answered question Q25 in the questionnaire (acquiring knowledge from vocational subjects) and question B4 (creating the structure of the text).

Table 6. H6 hypothesis testing result (contingency table)

Pearson's chi-squared = 0,331336 degree of freedom = 1 significance p = 0,564874			
Question 25/B4	Yes	No	Line totals
Yes	41 (43,66)	118 (115,34)	159
No	93 90,34)	236 (238,66)	329
Column totals	134	354	488

Q25 – acquiring knowledge from vocational subjects, QB4 – creating the structure of the text.

Hypothesis H6 stating that "pupils who acquire knowledge from vocational subjects rather than through self-study create the structure of the read text more frequently than pupils who do not acquire knowledge from vocational subjects rather than through self-study" has not been verified (Table 6). It can thus be stated that the structuring of the text by pupils, if it occurs, is not tied to the autodidactic or hetedrodiactic way of acquiring knowledge and can thus take place in both forms.

5 Discussion and Conclusion

The results demonstrate the current state of reading strategies of secondary vocational schools of engineering students in the Moravian-Silesian Region of the Czech Republic. Actors influencing the level of understanding the information (e.g. teaching strategies and learning strategies of teachers, pupils' reading strategies, emphasis on the student: understanding the meaning of individual words, understanding the meaning of the whole text, understanding the meaning of parts of the text, understanding the meaning of parts of the text and the whole text, understanding the content and form of the text) were identified. The research supported the need to work with texts for everyday experience, create pupils' home libraries, develop their critical and technical thinking. It also emphasised the development of pupils' metamotivation and metacognition to reading comprehension and strategic thinking. The sample of Czech pupils uses identical or related reading strategies when working with both paper and digital text forms.

The research has shown a statistically significant relationship: between the student's reading for cognition and the preference of a specific topic, between the student's ancillary questions when reading or after reading the text and the their search for context about the information, as well as between students' reading strategy and their evaluation of working with the text for everyday experience. The research has not shown a statistically significant relationship between the pupil's ability to create the structure of the text and asking questions while reading and after reading the text, between teachers of vocational subjects' guidance to think about a technical problem and the pupil's search for connections about the information. The relationship between the pupil's acquisition of knowledge from vocational subjects rather than by self-study and their use of ancillary questions while reading and after reading the text has not been confirmed as well. Other researches have dealt with reading literacy or reading strategies of primary school pupils (Sandberg and Norling 2020 and Genlott and Grönlund 2013) and lower-secondary school pupils (Sieglová 2017). According to Oakhill et al. (2014, p. 4) "The ultimate aim of reading is not the process but to understand what we read and comprehension can take place at many different levels". Research (Trávníček 2017) has dealt with the problem of reading and media literacy through the lens of four reading generations of contemporary Czech society. The curriculum of Czech secondary school studies should aim to strengthen the links between technical studies and everyday reality, the need to understand texts, respond to dynamically changing reading needs and interests with regards to the requirements of the emerging digital generation. The professional competencies of secondary vocational schools of engineering graduates should be based on the interest of learners in the technical profession, digital technologies, processes of automation and robotisation, digitisation reading comfort, communication and reading rationality, strategy and interest in lifelong learning.

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Specializing the Teacher Training on a Chilean University and Vocational School: The Case of INACAP

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Abstract. INACAP is a Chilean university of applied sciences and vocational school (post-secondary education) with more than 27 campuses in different regions of Chile, that offer programs in informatics, mechanical, electrical, and civil engineering among others. Frequently, the teacher training programs in INACAP are designed from a generic vision of pedagogical competencies and not necessarily specialized for a particular discipline. This article contextualizes this situation with an analysis about the contemporary training programs for the development of pedagogical competences of the academic staff of INACAP, and at the same time exposes the results of a survey about teaching needs on Engineering Pedagogy in engineering departments of INACAP. In general, the instrument and indicators seek to obtain information about: (i) experience and needs related to engineering didactic fundamentals, (iii) requirements for the structuring of teaching - learning processes in a university context, and the setting of objectives and contents of an engineering degree among others. Based on these results, a teacher trainings program for the academic staff of the engineering schools was designed. The project is led by the International Center of Engineering Education (CIEI) at the University of Talca (Chile) in cooperation with the academic staff of INACAP Talca, under the pedagogical support of the Technische Universität Dresden (Technical University of Dresden, Germany), Faculty of Education.

Keywords: University Teacher Training · Engineering educators training · Engineering Pedagogy

1 University Teacher Training in Engineering Faculties

1.1 Chilean Context

The pedagogical competences of the academic staff are undoubtedly a key factor in the success of the professional training of students of universities and vocational schools.

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However, despite the dual profile of the professional work of university teachers (teacher and researcher), aspects of teachers' research competencies are generally emphasized over the educational-pedagogical profile [1, 2]. To compensate this situation, the universities and vocational schools design a series of training programs and courses for their academic staff, that seek to strengthen the pedagogical competencies regarding the design and evaluation of teaching-learning processes, the implementation of various active methodological strategies and the generation of "new" teaching resources, among others. Pérez Rodríguez (2019) characterizes the situation of teacher training programs in Spanish universities, noting that most of the programs consist of general courses, which are principally aimed at promoting the pedagogical competences, as well as the analysis and reflection of the teaching task itself. The author elaborates on this idea in the conclusions of her research, where she emphasizes that the majority of university teachers receive "training that is little linked to their practice and disconnected from their classroom experiences" [3]. In the Chilean university context, there is not yet a complete scientific review of all the training programs for university

Table 1. University teacher training program at University of Chile [4]

Module	Goal
1. Higher education: contexts and challenges	To analyze the current and future characteristics and challenges of higher education in Chile, Latin America and the world
2. SoLT (Scholarship of Learning and Teaching)	To identify the implications of the SoLT model in the development, research and innovation in higher education
3. Teaching for high quality teaching-learning in higher education	To establish the implications and scope of high quality and effective teaching and learning, based on empirical evidence, in the context of higher education and the challenges of the society
4. Innovation, active learning and ICT's	To implement active methodologies within the classroom, considering current teaching trends, especially from the disciplines themselves
5. Learning committed to the environment and the community	To design teaching processes linked to the community and the environment, that are related to the disciplinary learning and the corresponding graduation profile
6. Classroom management in contexts of diversity	To implement actions, within the classroom, that consider heterogeneity and inclusion, capable of committing to the learning of each and every student
7. Education with a focus on gender and sexual diversity	To generate a holistically and comprehensively understand of the teaching and learning processes, from the perspective of gender and diversity (LGTBIQ)
8. Evaluation of learning outcomes in higher education	To produce assessment instruments and situations, according to collect evidence of student learning outcomes in higher education

and technical teachers. There is public information disseminated by institutions that accounts for pedagogical training programs oriented to all disciplines. Table 1 exposes an example of the University of Chile [4] with a typical teacher-training program in the contemporary Chilean university context.

In general, the training courses are characterized by an educational sciences perspective, accompanied by contents related to the demands of Chilean society in the 21st century. However, the question remains about the degree of effectiveness of this kind of courses for the teacher training and its real "closeness" with the disciplinary reality of the different modules at students training programs (engineering sciences for instances).

1.2 The Case of INACAP

The current national and international scenarios, related to the new regulatory framework for higher education in Chile (Law No. 21.091/2018) and Industry 4.0, have motivated INACAP's Higher Education System (University and Vocational School) to develop a teacher's training program, that meets learning needs of future technicians and professionals along with the country. INACAP has an institutional training plan for teachers and its academic staff with the purpose of updating their technical and pedagogical competences. Further, it pursues to promote pedagogical innovations that impact significantly the learning process of students.

The courses of the training plan are organized in two learning progression levels: advanced and expert. The first is focused on the development of a diploma about teaching in higher education and a plan to improve basic teaching skills. The second is focused on post-degree development and specialization within academic areas. The teachers training is based on three principles: (1) to create connections between teachers and the industry, in order to build learning scenarios for their students, (2) to provide teachers with experiences in the industry, so as to empower them with technical skills and thereby promote innovation projects from the classroom to the industry, and (3) to assume and apply teaching technologies. The training proposal is completely centrally defined and it is delivered mainly online for the purpose to achieve coverage in all the 27 campuses throughout the Chilean territory (Table 2).

Table 2. Overview with INACAP Training's plan for teachers and academic staff.

INACAP Training's plan for teachers and academic staff		
Program	Course	Objective
Diploma Teaching in Higher Education	Teaching in Context of Higher Education in 21'st Century	Ponder on required teaching competencies to face the paradigm change caused by competence training
	Neuroeducation	Set up a dialogue between neuroscience and its contribution to education, in order to improve proposals and learning experiences

(*continued*)

Table 2. (*continued*)

INACAP Training's plan for teachers and academic staff		
Program	Course	Objective
	Innovation	To bring the teacher closer to an innovation process that mainly describes networking through INACAP ecosystem to promote innovation and entrepreneurship
	General Didactics	To bring teachers closer to new teaching-learning processes and procedures linked to the competency-based approach and use of technologies
	Learning Evaluation	Provide assessment tools necessary to improve student learning with a competency-based approach
	Teaching Learning Planning	Provide teachers with the curricular knowledge needed to improve their students learning within a competency-based approach
	B- and E-learning teaching	Provide theoretical elements necessary for blended and online teaching
Post degree Teaching in Upper Technical Education	Innovation Upper Technical Teaching Digital courses/module General Didactics Learning Evaluation	Promote innovation and inter-disciplinary work, adapting to the new regulatory scenarios of higher education for upper technical training
	Certification Alternative Credentials *Miriadax Teaching* in Upper Technical Training	Higher level of contents and methods for each course

Within this teacher training and development plan, INACAP generated a cooperation strategy with CIEI (University of Talca). The aim of the project is to strengthen specifically Engineering Education and Vocational Education, through the training and certification of teachers and academic staff in two areas: design of teaching-learning processes and evaluation of learning processes and outcomes.

1.3 Engineering Pedagogy at Chilean Universities

The research project Engineering Pedagogy at Chilean Universities (PEDING 2014–2018) offered, for the first time at the Chilean context, a scientific discussion about the concept of Engineering Pedagogy and established clear guidelines and concrete activities for its installation and development of the Engineering Pedagogy at the

Chilean university context [5]. The project tried to improve the quality of the engineering education through the participation of the engineering teaching staff at a needs-based continuing education training program. The course presented a specific orientation to engineering education and was specifically aimed at teaching staff of faculties of engineering, with modules built and structured specifically for engineers and included relevant examples for this group [6]. The training course consisted of six modules according to the curriculum of the training program “International Engineering Educator ING.PAED.IGIP” of the IGIP center at the TU Dresden, Faculty of Education. The course consisted of the following modules each of 1,5 SCT-Chile (ECTS):

1. Teaching and Learning Process Design in Engineering Education (EE)
2. Communication – Design of communicative processes in Teaching and Learning
3. Didactic Media in EE
4. Control and Evaluation of the Learning Results in EE
5. Laboratory Didactics in EE
6. Project-Based Learning (PBL) in EE.

Because the participants of this training course were from different Chilean universities in different Chilean cities, the face-to-face sessions were carried out via video streaming (REUNA-ZOOM). Autonomous and collaborative work was promoted through the use of technological tools in the course platform (Moodle). The evaluation was primarily formative and the lecturer of each module requested a final product that allowed to demonstrate the developed competences of each participant [6].

2 Engineering Pedagogy Needs at INACAP

2.1 A Needs Analysis on Engineering Pedagogy at INACAP

Based on their work at the PEDING research project, Gormaz-Lobos und Galarce-Miranda (2020) developed categories and indicators, which later were used in the data collection instrument about the teaching needs of the engineering schools at INACAP campus Talca. In general, the instrument and indicators seek to obtain information about: (i) the characteristics of lecturers (years of experience, subject matter, etc.), (ii) the needs related to engineering didactic fundamentals, (iii) the requirements for the structuring of teaching-learning forms in a university context, (iv) the knowledge and experiences at the development of teaching-learning strategies in engineering, (v) requirements for the setting of objectives and contents of engineering programs, and (vi) the identification of strengths and weaknesses, together with the conditions to enroll in a training course (see Table 3) [6, 7]. The results of this research about the needs in engineering pedagogy were used in the development of a pilot training course oriented specifically for the staff of the engineering schools at INACAP. The training program was designed based on the module structure according to IGIP curriculum (International Society for Engineering Education) and the guidelines of the Technische Universität Dresden, Faculty of Education.

2.2 Methodology

The survey was designed using a mixed model of qualitative and quantitative methods. Through a concurrent triangulation strategy, Creswell (2003) states that quantitative and qualitative data can be collected simultaneously. The aim is to use two different survey methods to confirm, supplement, or validate the research results [8]. The main goal of the design was to integrate the opinions of the participants (academic staff) with the assessment of engineering-pedagogical needs that are most required for the teaching-learning process of engineers.

2.3 Population and Available Sample

The sample of the study was composed by 26 academics of four Engineering Schools of INACAP campus Talca: Industrial Engineering, Mechanical Engineering, Electrical Engineering and Information and Computer Engineering.

2.4 Instrument

The survey instrument was an opinion poll type instrument with open and closed questions, oriented to identify the perceptions about the teaching needs of different pedagogical aspects related to the engineering subjects at INACAP. The main goal of the instrument was to identify the training needs and interests in the pedagogical and didactical aspects and requirements of major importance for the formation of engineers. Table 3 shows the specific categories and indicators of the instrument.

Table 3. Instruments Categories and Indicators for Needs Analysis in INACAP (Gormaz-Lobos and Galarce-Miranda, 2020).

Categories	Indicators* (simplified version for this publication)
I.1. Design of teaching- learning processes in engineering sciences	I.1.1. Psychological bases of teaching and learning I.1.2. Theoretical/practical bases of engineering didactics I.1.3. Didactic Principles in engineering education (EE) I.1.4. Organisation of the T-L processes in EE I.1.5. Structuring of the teaching – learning processes in EE
I.2. Didactic media for teaching in engineering	I.2.1. Concepts and classification of didactics media in EE I.2.2. Functions of didactic media and technological tools I.2.3. Field of action of didactic media I.2.4. Elaboration of didactic media in EE

(*continued*)

Table 3. (*continued*)

Categories	Indicators* (simplified version for this publication)
I.3. Communication	I.3.1. Design of communication processes I.3.2. Monologic and dialogic communication procedure I.3.3. Conflict identification and resolution
I.4. Control and Evaluation of the learning outcomes in EE	I.4.1. Registration and evaluation of the learning outcomes I.4.2. Operalisation of learning outcomes in EE I.4.3. Procedures for the registration of learning outcomes I.4.4. Evaluation of the learning outcomes in EE
II.5. Lectures (theoretical courses)	II.5.1. General structure of a university course planning II.5.2. Preparation of a university course II.5.3. Execution of a university course II.5.4. Feedback in a university course
II.6. Laboratory practical training/self-study	II.6.1. Laboratory training II.6.2. Experiment functions in the T – L processes II.6.3. Exercises and self – study planning
II.7. Engineering internships, written reports, research colloquium	II.7.1 Engineering internship preparation and research preparation II.7.2 Support systems for internships and for autonomous research II.7.3. Internship analysis and research activities analysis
III.8. Determination of the study program objectives	III.8.1. Analysis of the activities in engineering III.8.2. Analysis of the activities related to an university engineering study program III.8.3. Analysis of social aspects in engineering III.8.4. Analysis of personal aspects in engineering
III.9. Determination of the engineering study program contents	III.9.1. Fundamentals for the determination of contents in EE III.9.2. Contents determination of an university study programs in EE with regard to the academic activities III.9.3. Contents determination of an university study programs in EE with regard to the personal activities III.9.4. Contents determination of an university study programs in EE with regard to the personal activities

2.5 Procedure

The first phase of the research process corresponded to information collection of the closed questions. The statistical analysis applied was exploratory-descriptive to raise problems. The second phase of the study examined the open questions of the sample through a textual content analysis by codifying the discourse of each academic, based on the item generating conceptual categories. The instrument was individually applied, considering the ethical aspects according to the Chilean social sciences research criteria.

2.6 Characterization of the Sample

The selected sample of academics that participated in the survey was approximately 20% of the total number of academics attached to each Engineering School at INACAP. In total, 26 academics were gathered with 35% women (9) and 65% men (17). Of the total respondents, 92% were engineers by profession (24), the rest had similar professions that help to complement the total training of the future engineers. Regarding the age ranges of the respondents, 73% (19) of the survey participants are between 30–39 years old and 11,5% (3) are over 50 years old.

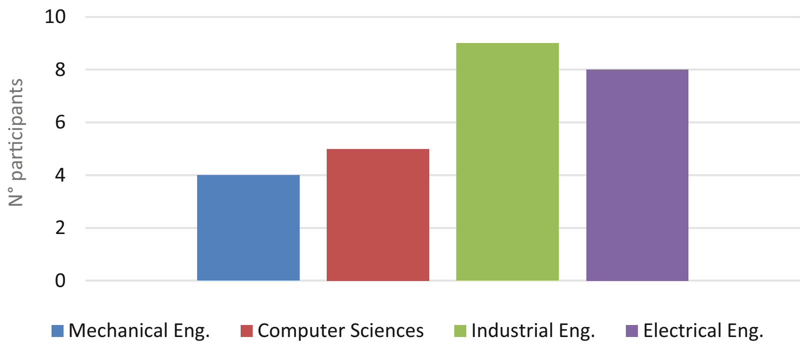

Fig. 1. Participant's distribution by engineering school at INACAP campus Talca.

Concerning the years of teaching experience, over 54% is between 1–5 years (14) and 30% is between 6–10 years (8). Of the total number of participants, approximately 70% (18) have already participate on university teaching trainings. Figure 1 presents the participant's distribution by engineering school at INACAP campus Talca.

2.7 Results of INACAP's Survey

Closed Questions. The results about the perception of the respondents regarding the need for different skills and pedagogical tools for university teaching in engineering careers are presented in this section. It was asked "*How necessary do you consider the following aspects of engineering pedagogy concerning your teaching experience?*" For this section, 28 aspects were considered based on the indicators of Table 3.

The relevance of the different aspects about needs in Engineering Pedagogy is presented in Fig. 2. All aspects were considered relevant for more than 75% of the participants. The most relevant are related to the evaluation methods, among which

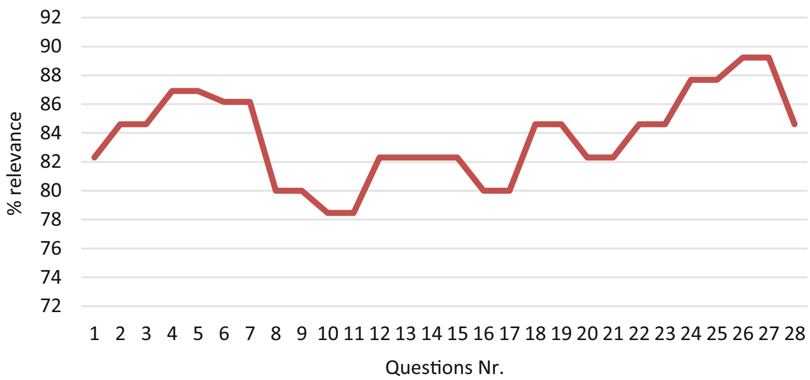

Fig. 2. Relevance of the different aspects about needs in Engineering Pedagogy.

stand out with more than 86% of the preferences aspects such as: *"Evaluation and assessment of achieved learning"* and *"Knowledge about design for effective measurement of achieved learning"*. Then with more than 82% of the preferences: *"Use and development of new didactic means in the training of engineers"*, *"Structuring of teaching-learning processes in the scientific training of engineers"* and *"Use of didactic resources and information and communication technologies (ICTs)"* for instance: "*Knowledge about procedures of collection and measurement of achieved learning"," Knowledge about collection procedures and measurement of achieved learning" and "Support elements such as projector, blackboard, materials, etc."*.

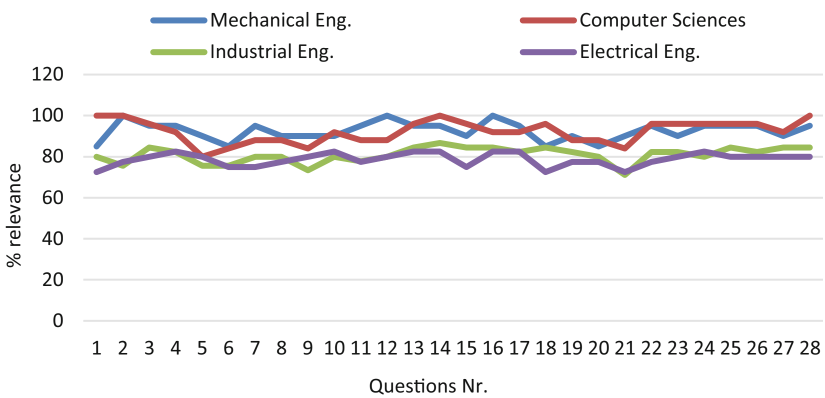

Fig. 3. Relevance of the different aspects about needs in Engineering Pedagogy by school.

Regarding to the results obtained in the 11 questions about strengthening of teaching methods (see Fig. 3), respondents considered all aspects with relevance over 70%. Among the aspects considered, the most relevant are: "*Design, choice and use of didactic means*", "*Use and development of new didactic means in the training of* *engineers",* and "*Planning and structuring of teaching-learning processes at university level*", all of them with more than 75% of the preferences by engineering schools. The aspects with the lowest relevance were: "*Curriculum development for academic training at the university level*", "*Planning and materialization of evaluation and evaluative processes*", "*Resolution of specific problems on the design of instruments for the assessment of teaching-learning processes*" and "*Realization of communicative processes for teaching at university level".*

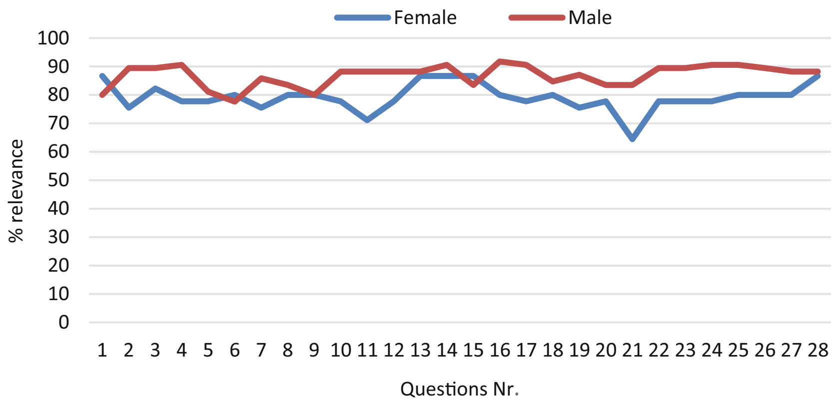

Fig. 4. Relevance of the different aspects about needs in Engineering Pedagogy by gender.

By grouping the participants by gender (Fig. 4), the female participants (9) have more than 86% of preferences on aspects related to "Evaluation" and " Teaching and learning structuring", for instance: "*Evaluation and assessment of achieved learning*" and "*Planning and materialization of evaluation and evaluative processes*" but also "*Structuring of teaching-learning processes in the scientific training of engineers*". The worst evaluated aspects by the female gender correspond to the "*Knowledge about the design of didactic means for the teaching-learning processes*" and "*Dialogic and monological communicative processes for teaching*", with 70% and 65% respectively.

In the case of men (17), the most of the aspects were considered with a relevance over 85%. The aspect "*Use of didactic resources and information and communication technologies (ICTs)*", and "*Development of didactics media in EE*", "*Recognition and resolution of conflicts within the classroom*", "*Planning of activities for individual study*" have preferences of 90%. Other high valued aspects (over 86%) are "*Evaluation and assessment of learning achieved*", "*Knowledge about the design for effective measurement of learning achieved*". For males the worst evaluated aspects correspond to "*Psychological foundations for teaching and learning*" and "*Knowledge about strategies to support professional practices and independent research activities*" with 80% and 78% respectively.

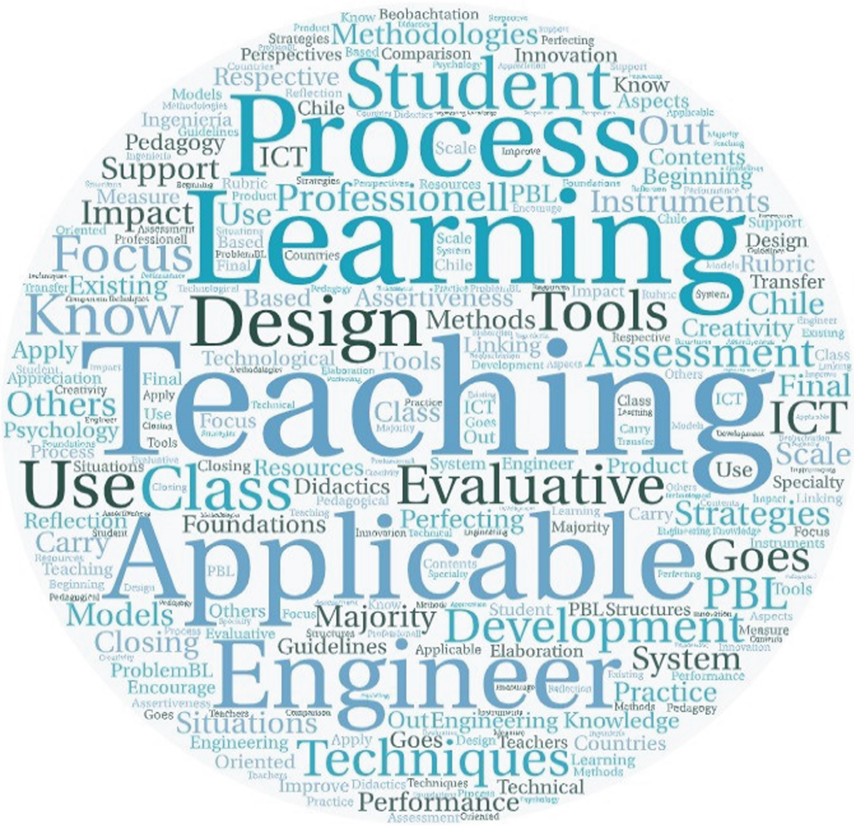

Fig. 5. Different aspects about interest in a teacher training in Engineering Pedagogy.

Open Questions. This part of the survey presented the answers of the participants regarding four aspects: (1) strengths in engineering pedagogy; (2) aspects to be improved in the teaching task; (3) interest and availability to train in the engineering pedagogy area; and (4) conditions necessary to attend a training in engineering pedagogy.

Regarding the strengths of the teachers in the sample, the three most relevant results are grouped in strengths associated with: The *organization of teaching-learning processes in the scientific training of engineers* (28%); the *structuring of teaching-learning processes in the scientific training of engineers* (21%) and the *knowledge for the determination of contents of teaching in Engineering in relation to personal, technical and social fields of the work of Engineers* (19%).

Concerning the aspects to be improved in teaching, these can be organized in three most relevant categories: *Evaluation and assessment of achieved learning* (35%), *Fundamentals for the determination of technical contents within the area of engineering* (22%) and *Knowledge and skills for the preparation, execution, and feedback of teaching* (18%).

Regarding the interest to take part in a teacher training course, all the participants are interested in a training course this type, but 86% of participants will participate in a "more oriented" or "specific oriented" training course for engineering educators. The answers are presented through a word cloud obtained from a word repetition analysis (see Fig. 5). The design of a specific teacher training course should consider: applicable knowledge, dictated by a specialist with expertise on teaching and learning on engineering, promote the design evaluation of engineering education, with innovative methodologies and tools, focused on students of 21 century, among others.

3 Conclusions

This research project was aimed at showing the pedagogical and didactic needs and new possibilities of qualification for the academic staff who teach in engineering schools of a big Chilean educational institution like INACAP, which works at university and vocational school (post-secondary) level. Based on the knowledge and experiences in the field of Engineering Pedagogy of the TU-Dresden and the University of Talca, were presented various aspects and differences between generic training programs for university teachers and training programs focused on Engineering Pedagogy.

From the results, it is possible to conclude, that a training course on engineering pedagogy specifically oriented for the academic staff of engineering faculties has a high level of interest and motivation. The academic staff of INACAP sees the need for continuous learning to improve their teaching strategies and methods in the context of the demands of students and the society of the 21st century but from a specific view of the engineering educational context. For those reasons the academic staff of the International Center of Engineering Education (CIEI) at the University of Talca, designed a teacher training course specifically based on the detected needs. At the time of this publication, the course is still in the implementation process. It is hoped that its results will serve as a basis for the continued promotion of the academic training in Engineering Pedagogy in Chilean universities and vocational schools.

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Poster: Engineering Students' Personality Traits and Their Accommodation in Higher Education Process

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Abstract. Although the prospects of engineering higher education have stayed in focus of a public debate for a number of years, this matter remains relevant for the modern society.

Our research zooms in on identification of professionally relevant personality straits of current engineering students. The basic assumption underlying out research is the understanding that much depends on students' readiness, willingness, motivation, and personal qualities.

Therefore, an analysis of personality traits which are conducive to solving effectively professional challenges should be rather useful. Another important topic is development of such personality traits as a result of higher education in the process of following university courses.

Keywords: Personality traits · Engineers · Students

1 Introduction

The engineering profession embraces versatile professional activities which imply knowledge of various scientific fields and different skills including long attention span, systemic and abstract thinking, persistence, creative approach and patience at the same time [13]. As we know, an engineer can face in his professional life the necessity to effectively tackle both managerial and leadership challenges as well as administrative tasks and economic problems [11], resolve conflicts at different levels [14].

2 Goal

Therefore, it has been the goal of our research to identify which personality traits nowadays engineering students possess and formulate recommendations on taking those into account when structuring higher engineering education in order to obtain maximum result.

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3 Materials and Methods

Our research covered personality traits of the students, who are following engineering programs at Kazan National Research Technological University ("KNRTU"), and which traits will be professionally relevant in their future practical work. In order to achieve this, we used the following methods.

Psycho-geometrics – a relatively young methodology of personality analysis which allows to assess and forecast certain personality traits, behavioral models and lifestyles. It was developed in the USA in 1978 by Susan Dellinger [2, 3].

Psycho-geometrics is based on five personality types which are matched with geometrical shapes. Many studies have pointed out that the diagnostical accuracy of the psycho-geometrics reaches as high as 85%. The suggested test allows to determine the personality shape and type, give a detailed characteristic of personal qualities and behavioral peculiarities of a given participant, draw up a behavioral scenario for each personality shape in typical situations [4].

All the test participants were segregated in five groups based on the test results, and we have compared important features of each group with their answers to questions from the following tests.

The first test – the questionnaire by Kenneth Thomas "Determining approaches to conflict resolution". This test represents one of the most widely spread diagnostics techniques allowing to predict a person's behavior in a conflict (to be more precise, in a conflict of interests). K. Thomas based his model on the assumption that people should not avoid conflicts or resolve them at all costs, but rather should efficiently manage conflicts. Together with Ralph Kilmann he put forward a two-dimensional model of conflict handling: the first dimension being person's behavior based on his consideration of other people's interests; the second dimension – behavior based on ignoring interests of others and aimed only at protection of one's own interests. (In Russia this methodology was adapted by N.V. Grishina).

Thomas distinguishes five approaches to conflict resolution along the abovementioned two dimensions (Assertiveness and Cooperativeness): competing, accommodating, compromising, avoiding and collaborating. The test illustrates tendencies of a certain person towards specific behavioral models in conflict situations [7]. This methodology is widely used in pedagogy in order to assess a person's behavior in a conflict and to teach the right responses in a conflict [1, 6, 10].

The second test – test of intellectual potential and creativity. The test description claims that the questions of this technique can test the participant's curiosity boundaries, self-confidence, loyalty, aural and visual memory, striving for independence, capacity to concentrate and focus. These personal features, as the author of the test asserts, characterizes a person's creative potential [9].

The third test, which is called "A leader or an administrator" (the author E.S. Zharikov), allows to detect in the test participants which of the qualities prevail in them – leadership or administration. The test participants are presented with 20 quotations which they are asked to assess at the 11-grade scale; this should help to determine leadership and administrative qualities in the participants [5].

4 Results

The test participants (the total number of 100 students) were distributed among the following personality shapes: 14.9% manifested the features of a “box” personality shape, 29.7% - the “triangle”, 18.8% - the “circle”, 8.9% - the “rectangle”, and 27.7% - as “squiggle”.

As we can see, the prevailing part of the students fall under the psycho-types of the “triangles” and the “squiggles”. These are relatively active personalities, whose behavior is underlain by striving for leadership and application of non-standard, original and creative approach. The least of the participants manifested the traits of the “rectangles” who are “people dissatisfied with their current lifestyle and looking for a better situation in life”.

We start the test result description from the group which was labeled by S. Dellinger as the “box”.

People of this psycho-type are described as very hard-working, diligent, accurate and patient. They like order, methodical at what they do, real erudites, and are prone to constant ruminations and collection of data. These people process this data, calculate the results by using logic but not intuition. They do not like excessive emotions but do like to plan and line up things. They are good in administrating and carrying out the tasks given by the others.

From our participants around 15% were diagnosed as the “boxes”, and we further analyzed them using the Thomas’s questionnaire.

According to the test author’s opinion, ideally each person should score between 5 and 7 on elements of all five styles in conflict; those styles which score more than 7 are being overused by the test participants, and those scoring below 5 – underused. This led us to conclude that the “boxes” are prone to compromise too often and quite rarely use the competing style in a conflict.

The “boxes” use most frequently the behavioral styles of “compromise” and “collaborate”, and definitely underuse the “compete” or “avoid conflict” styles as they are oriented towards looking for a problem solution.

The intellectual potential and creativity test has shown that the participant from the “box” group possess the qualities which allow them to create, but they have limitations for their creativity. We could not detect too high creativity potential among the participants of this group; however, on average this group scored quite fine on this test.

The “leader or administrator” test showed that on average this group can combine leadership and administrative qualities, but the latter are developed slightly more prominently.

As we can see, the results of different tests do not contradict, but rather complement one another in giving an accurate picture of this group.

The next group is the psycho-type “triangle”. In our sample it is 29.7% of the students.

People of this type are described as self-confident, strong, unrestrainable, active personalities, who set clear goals and reach them. To be a leader is in their DNA. They will contest and compete with others on their way to attaining their goals. They are set on winning, sometimes at all costs. They are impatient, intolerant, do not like to make mistakes, ambitious, smart, intuitively feel their benefit, brilliant executives.

Testing of the participants of this group on the Thomas questionnaire yielded the following results: the "triangles" would use most often styles of "compromise" and "collaboration", and the least – "compete". Moreover, considering that each style should score between 5 and 7 points, it turned out that the "triangles" overuse compromising and do not compete enough.

The intellectual potential and creativity test has shown that the participants-" triangles" have the same qualities as the "boxes". The general test results are basically the same. We can also talk here about limits to creativity and about presence of creative abilities, although not outstanding.

The "leader or administrator" diagnostic showed on average prevailing leadership qualities.

As we can see from the analysis above, the "triangles" are similar to the "boxes" in some of their traits but manifest more leadership qualities rather than administrative. Leadership of the "triangles" is not aggressive, not competing and contesting, but reasonable, based on choosing the best from a range of options. The "triangle" would not compete and use his energy where he can compromise or collaborate in order to solve a problem. He is a politician and a strategist.

The psycho-type "circle", as it is obvious from the definition, does not have any corners. This stands for peace and understanding. These people possess exceptional communication skills, in every situation trying to reduce conflicts to a minimum. These people have empathy, are well-meaning, moralists, strive for justice, and most of the time stabilize the group. They cement together a group, have interests of each group member at heart. In our sample 18.8% of the students were identified as this psycho-type.

Analysis of the test participants' answers to the Thomas questionnaire showed that the "circles" in a conflict situation would often accommodate (6.7 points), rarely compete (4.77 points), and equally often resort to avoiding (6.2 points), compromising (6.1 points) and collaborating (6.1 points).

The creativity test has shown that a typical "circle" believes that the world around us can be improved, and that they can themselves contribute to this improvement. Some of their ideas can be helpful in that sense.

The leader or administrator test has demonstrated that among "circles" both the leadership and administrative qualities are well developed, while the leadership qualities scored higher.

A typical "circle" believes that he can get along even with "difficult" people, that undivided authority is at the root of a group's success. He tends to make decisions himself if a discussion of an important matter for the group would take too much time; at the same time, he agrees with the opinion of the other personality types that a group should choose its own manager.

To conclude, a typical "circle" in our research fits with the Dellinger's description of this type in that he is group-oriented, can yield in the interest of the common good; however, he possesses not only administrative qualities, but also leadership qualities and, under certain circumstances, can assume the role of a leader.

5 Discussion

The transitional personality shape – “rectangle” in our sample came up only in 8.9% of the cases.

According to Dellinger, all other personality shapes can try on temporarily the “rectangle” type if they are under stress or in search for themselves. They can listen to others, are curious, can adopt others’ opinions, can be inconsistent and unpredictable. They can be either infantile, or actively manifest traits of other personality traits which may alarm people around them. At the same time, the “circles” need interaction with other people.

The Thomas test results for the “rectangles” in our sample showed that people of this type very frequently accommodate (8.7 points), and hardly ever want to compete in a conflict (0.7 points). He would also quite often compromise in a conflict (8 points). Within the norm is the frequency of use of collaboration (6.7 points) and avoidance (6 points) approaches in a conflict.

The creative potential test showed that the “rectangles”, as well as the other personality shapes, do have this potential which, however, does not translate in prominent creative abilities. Creativity limits are also present.

The “leader or administrator” test revealed that a typical “rectangle” can act for the sake of the common good; people would generally confide in him; when it is really necessary, he can take a stance which the other people will respect and yield to.

To sum up, the “rectangles” in our sample would be ready to yield and compromise; however, despite the remaining doubts, if the situation demands they would be ready to assume the role of an arbiter in a conflict and make the others to accept their opinion. The leadership qualities in the “rectangles” are slightly more prominent than the administrative. At the same time, considering that this personality shape is prone to accommodate and avoid in a conflict situation, he would not feel himself very comfortably in a leader’s role – he can accept this role only if the circumstances dictate so.

The last psycho-type is the “squiggles”. According to the Dellinger’s description this is an original, sometimes shocking, creative personality which gash forth different ideas. They mostly rely on their intuition and value aesthetic side of things. They are generally well educated and combine in them integrative and fragmented approaches. They do not follow the strict logic in their deductions. Therefore, the other personality shapes have difficult time trying to understand the “squiggles” (which we also witnessed in our research). Most of the test participants noted that it would be difficult for them to interact with the “squiggles”. The “squiggles” are the most exuberant and enthusiastic of all the personality shapes. When they get a new idea, they have to share it with the world. They are not very good politicians – vulnerable, constantly changing, and inconstant. They can motivate people while an idea is burning bright in their hearts, but once the novelty is gone, so is their enthusiasm to carry on with this idea which may result in project being left unfinished.

The Thomas’s test showed that the “squiggles” are the least likely to accommodate (4.9 points); they are not striving for competing but are ready to contest and compete more than the other personality shapes.

Moreover, they are also ready to avoid conflicts; however, once they are in a conflict, they would be also ready to collaborate and compromise.

On average, creative potential of this psycho-type is not exorbitant and falls into the norm, as is the case with the other types.

The "leader or administrator" test showed that the "squiggles" have more prominent than the other shapes both leadership and administrative qualities; however, the administrative qualities are slightly more visible.

People of this type can take a stance which would make the others to accept their point of view. They are often entrusted with representing and acting on behalf of a group. They also consider that if a matter can potentially bog down in lengthy discussions, they would rather take the decision single-handedly. However, the "squiggles" believe that the law is law for everybody, that people would only benefit from an "iron-hand management" style, that if needed they would be able to make people work and to lead a group.

In general, as we have seen, a typical "squiggle" is self-confident, full of ideas, and would not shy away from assuming a leadership role.

As a result, we can see that the detailed analysis of the personality traits of the detected personal types has shown some discrepancies in types' features; however, on average groups' characteristics were consistent with the general picture described by Dellinger in her research.

We have also run a statistical analysis of the answers given by the five participant groups on each of the tests which gave us material differences on certain criteria (for example, certain material criteria were detected at the level of $p < 0.05$ by U-criterion of Mann-Whitney, as well as at $p = 0.03$ of Kruskal–Wallis' ranking DA).

6 Recommendations

The study of students' personality traits in light of their professionally relevant qualities which will be important in their future career as engineers allowed us to put forward several recommendations on structuring the education of these students:

1. Ensure that students have the opportunity of doing internships in at least two different companies where they will be exposed to working in several different work teams managed by people of different psycho-types. Moreover, if a student receives a positive feedback during one of the internships, he or she might later land a job in one of these companies.
2. Arrange the flexible schedule of course paper submission by students which will be based on effective time-management principles and accommodating the student's abilities and personal preferences. That will contribute to developing independence and responsibility in students.
3. Allow the students when working on a project or an assignment to choose the role of a leader, manager, or administrator with the respective ambit of responsibility for the end result of the project, which might also need to get approval by the company where the student intends to do the internship. That would allow the students to try on different roles, in particular a role of a leader or an administrator and feel the

difference between the job responsibilities of employees of different levels in a company.
4. Give students more room for independent and proactive approach in the educational process by allowing them to engage in self-education, to take on-line courses if a student feels a need for this additional training or has a limiting disability.
5. Seek opportunities of including students in some real-life projects which the university carries out for their partner companies or scientific funds so that students' creativity and teamwork skills will be developed as the students acquire certain experience [5, 15].
6. As the students come to realize their roles in such a project and their educational and intellectual capacities, they should be allowed to vary their job functions and the tasks they fulfill in the adjacent areas of their study and research activities [12].

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Self-concept as an Activity Factor in the Social Networks of the Polytechnic College Students

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Abstract. The paper presents the results demonstrating the distinguishing features of interconnections between self-concept and the specifics of activity of polytechnic college students in social media. The distinctions of college students' self-concept were investigated. The marked components in the self-concept framework include "Active Self" and "Reflective Self", which is due to the strive of young people to understand their position and purpose in this world and because their perception of themselves as being unique and having their own potential is actualized. The paper considers the gender specifics of the self-concept framework, which shows a trend towards polarizing the self-image based on the traditional gender norms of young people at this age. It is shown that self-concept plays an important role in determining the activity pattern in social media. It has been established that such components of self-concept as "Material Self", "Communicative Self", and "Prospective Self" mediate realization of the need to communicate and expand social experience through social networks.

Keywords: Self-concept · Social media · Adolescence · Internet activity

1 Context

Rapidly developing information technology has essentially transformed the living environment of modern man and facilitated the way many problems are dealt with, starting with the search for the location of an object in real space, optimizing the process of interaction with state agencies and bodies and finishing with the extension of opportunities for creative self-fulfillment and self-actualization.

However, widespread use of the Internet, growing engagement of an individual in social media entail a number of risks: negative and dangerous content, speculation in trust, losing personal data, cyberbullying. Teenagers and young people are especially vulnerable to Internet threats since their self-identity, self-relationship are not fully formed and they have not mastered coping behavior and self-regulation techniques yet.

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2 Purpose

We find it reasonable to identify as topical the problem of the influence of the Internet, virtual environment and digital technology on the processes related to the formation of identity and self-concept, cognitive and social development, psychological well-being and psychological safety of youth today. It is worth noting that in spite of an interest in this problem and a range of meta-analytical reviews [1, 21], studying psychological mechanisms that explain behavioral activity of adolescents in social media still remains relevant to the most up-to-date research in psychology and education [2–4].

Thus, the aim of the research was to study the role of self-concept in the specifics of the activity of polytechnic college students in social media.

3 Approach

3.1 Self-concept: Structure, Age Dynamics and Influence of the Internet

Self-concept takes up an important position in the theories that explain human behavior and is considered as a certain set of attitudes an individual has with regard to himself, a system of ideas he has about himself [5].

The structure of self-concept is perceived in a very diverse way. So, B. Burns, C. B. Dobson distinguish 2 main components in the structure of self-concept: self-image, interpreted as a set of certain ideas an individual has about himself (the cognitive component of self-concept), and self-esteem, which shows the emotional attitude of the person towards his features, abilities, social roles (an affective component of self-concept) [5].

Relying on the classical works of W. James, R. Burns, and the works of today's scholars H. Markus, P. Nuris, S.R. Pantileev, V.V. Stolin, I.I. Chesnokova et al., M.G. Sinchurina combines different ideas about self-concept and suggest considering the following variables in the study of self-concept: components of self-concept, modalities of self-concept, levels of self-concept, temporary components of self-concept, distorting components of self-concept [6, p. 116].

The author refers the cognitive, affective, and behavioral components of self-concept to structural components. The main modalities of self-concept are represented by the characteristics that reflect self-image in a space of real and desired characteristics, and by how a person is seen by the others, in his opinion (real self, looking glass self and ideal self). The levels of self-concept reflect the person's self-image given the features of interaction with the physical, social environment, and given the developed world of ideas.

Adolescence is an important period in self-concept formation (E. Erikson, L. S. Vygotsky et al.).

Studying self-concept on the samples of college students showed that at this age one of the most important new formations appears in the structure of self-concept of students, which reflects the idea of their future professional role – professional self. Future self takes a significant place in the structure of ideas about self at this age. Various aspects of their future lives are reflected in the students' views, including family and professional roles [7, 8]. Researchers highlight that an important role in determining the behavior pattern of a young individual at this age is played by such a parameter of self-concept as ideal self, which has a significant impact on one's self-esteem [9]. The study carried out by Tkachenko N.V., Dudko A.A. showed that students in their later teens commonly have a stronger motivation for social approval, a low level of self-esteem. They value themselves less, and have a weakly differentiated negative attitude towards themselves in comparison with other students [10].

Modern research studying self-concept of students in their mid and late teens can be divided in the following groups: studying the specifics and the role of self-concept of gifted students [11, 12], studying the role of individual components of self-concept in predicting self-esteem [13], studying academic self-concept [14], studying the impact of gender and age on the specifics of self-concept [15], studying the role self-esteem plays in forming Internet-dependent behavior [16–19]. It was found out that the problems of self-identification are more frequent causes of the risk of Internet addiction among college students [20].

3.2 Online Activity

Among the main directions of research into human activity on the Internet the following are distinguished: distribution, reputational leveling, anonymity, mobility, hybrid behavior, immersion [21]. Human activity in social media are increasingly getting an issue of complex studies which combine psycholinguistics, psychology and sociology. Thus, studies of M. Kosinski and colleagues on such parameters of social networking in Facebook, as page likes and status messages, prove to be effective to reveal quite accurately sociodemographic and personality characteristics (e.g. attitude to alcohol etc.) [21].

E.P. Belinskaya points out that the Internet and social media are of great significance in socializing today's teens and adolescents. She indicates two main reasons for such an Internet impact: high impact of a communication component at this age group and an opportunity to pass rules and norms of interaction in the digital environment down to other age groups [23].

In recent time researchers have been interested in special phenomena of activity on the Internet, often associated with the violation of the psychological safety and information security of users. One of these phenomena is cyberbullying, interpreted as "…deliberate aggressive actions, taken systematically over a period of time by a group or an individual using electronic forms of interaction and directed against a victim who cannot easily defend himself or herself" [24, p. 180; 30].

Soldatova G.U., and Rasskazova E.I. found out that the dominant activity of adolescents on the Internet largely determines the degree of threat and risks of physical and psychological security, and the specifics of dealing with these threats in the virtual environment. So, adolescents who focus on using the Internet primarily for educational purposes are less exposed to various online risks. The ones who actively use the facilities of the Internet to search for information about sex are more likely to risk "meeting sexual content" and more likely to try to cope with the problems on their own [25]. Modern authors highlight the role of parents in teaching their children about the ethics of behavior and communication on the Internet, describe the main strategies of parental mediation when the Internet is used by adolescents [26].

Apart from this, each hypothesis provides a variety of mechanisms clarifying social networking of teens and adolescents. All the above-mentioned keeps the given research up-to-date.

3.3 Method

The research involved 62 students of Surgut Polytechnic College. Among the total number there were 36 male students (58%), 26 female students (42%). The age of the participants ranged from 15 to 20.

The method introduced by M. Kuhn and T. Mcpartland modified by T. V. Rumyantseva was used In order to study the parameters of self-concept [27]. The methodology represents a non-standard self-report. The categories of content analysis of the answers proposed by Rumyantseva T.V. were used to process the results of study. The authors worked out a questionnaire to study behavioral patterns in social networking [28]. The behavior was analyzed according to the following parameters: activity of social networking (estimated by the time spent every day on social networking); communicative expansiveness (estimated by a number of friendships in social media); openness and self-disclosure in social media (access limitations to a personal page) etc.

4 Actual Outcomes

Table 1 presents the mean group values for the indicators that show the features of self-concept in a group as a whole, and the level of significance for the differences in the values of indicators between boys and girls who took part in the research. Validity of outcome differences was determined by Mann-Whitney U-test.

Table 1. Mean group values for self-concept indicators

Indicator	Means (by group)	Means (girls)	Means (boys)
Social Self	1.8	1.7	1.9
Communicative Self	2.2	2.4	2.1
Material Self	0.9	0.7	1.05
Physical Self	2.8	4.6**	1.5
Active Self	4.8	3.7	5.7*
Prospective Self	2.3	3.8**	1.3
Reflective Self	3.7	2.7	4.4*

Note: *$p < 0.05$; **$p < 0.01$

In general, the data obtained suggest that the best presented components in the structure of self-concept of the polytechnic college students are “Active Self” and

“Reflective Self”. In the structure of self-representations, the dominant characteristics are the ones that reflect the future professional role and are associated with the current stage of professional self-determination, and the ones confirming that there are useful skills and abilities, and hobbies.

The analysis of the ratio of such self-concept elements as “Social Self” and “Reflective Self” suggests that the differentiating component of self-concept is dominant, and shows that the college students focus on emphasizing their own uniqueness, unusualness, uniqueness, and are aware what their place in the world is. The characteristics related to the features of the students’ own appearance (Physical Self) take a significant place in the structure of their self-concept, which can be explained by the fact that love relationships with members of the opposite sex are meaningful for the students and assessing appearance is important for young people on the whole. The role that appearance assessment plays in general self-esteem of young people is shown in the study by Baudson, Weber, Freund [13].

In general, the data obtained are consistent with the results of the well-known studies [13] and show the trends of change in self-concept common for this age, which means that the differentiating component of self-concept gets stronger, and there is an increase in the representation of professional roles, qualities, skills, relevant for professional activities in the general structure of self-concept. These tendencies are related to searching for and striving for realizing one’s place and mission in this world, and actualized ideas about one’s own uniqueness, one’s own potential.

According to the study of the gender specifics of self-concept, significant differences were discovered in the representation of individual components of self-concept among young men and women studying at the Polytechnic College.

So, such components as “Physical Self” and “Prospective Self” are more prominent for girls, which means that girls pay more attention to appearance and these characteristics are of greater importance for them. This fact can be explained by the influence of traditionalist norms, reflecting the importance of visual appeal as a significant resource women have when building a system of relationships with the surrounding society [29]. It is also possible to note a higher representation of characteristics reflecting aspiration for the future, the presence of plans and life prospects as a distinction of the girls that have been studied.

In the structure of young men’s self-concept, one can note a larger representation of such indicators as “Active Self” and “Reflective Self”. Boys are more focused on their own uniqueness, analyze their character traits and personal characteristics, notice their individual stylistic features of behavior in various situations, more frequently think about their own purpose, meaning of life, their own place in the world. It is also more typical for young men to describe themselves using the characteristics of action, intense activity. It is important for young men to have a favorite hobby, gain new experience and feel competent. Young men are more focused on assessing themselves through their abilities and achievements.

The noticed differences in the structure of self-concept between young men and women show a trend for polarizing Self-Image given gender perceptions and norms, and indicate that young men are more prone to feelings associated with identity crisis.

Investigating the activity of the polytechnic college students in social media made it possible to establish that they spend 3.61 h on social networking every day, using smartphones or PCs.

VKontakte is the most popular social medium among the students, with 95% of the total number of the study participants registered in it. 58% of the polytechnic college students have accounts on Instagram, 17% on Twitter. The popularity of Vkontakte can be explained by the existing wide geography of this network in Russia, its early appearance in the media space, and the fact that Vkontakte is actively used to solve problems of fast communication and information transfer, which also has a significance for the students.

The respondents are oriented on making new friends on social media. The number of friends is one of the indicators of their own attractiveness and a way to raise their own status. At the same time, the girls show a greater focus on expanding the communication network, communicative expansiveness (3.61) compared to the young men (2.58), with the significance of the differences being $p < 0.01$. It can be noted that according to the survey, the kids demonstrate moderate willingness to transfer virtual communication into real one, and they occasionally initiate (or support) the initiative of a face-to-face meeting with their virtual friends.

The students of the Polytechnic College note that they rarely feel alone in real life, so social media are not addressed to compensate problems in real communication or fill a communication vacuum.

The respondents do not tend to experiment with their own identity, creating pages with false information about themselves, admitting that they lack experience in doing so. The respondents tend to be cautious about self-disclosure, some of them limit access to their personal page for other people, which can be considered as a trend towards compliance with information security rules on the Internet.

According to the questionnaire survey, for a fact, the girls were significantly more likely to experience cyberbullying on social media ($p < 0.05$). This experience may be due to the higher communicative activity of the girls, their tendency to take initiative in Internet communication, and because of the higher importance of communication for them, the sensitivity to nuances of interpersonal relationships for girls in general, which often stimulates arguments, manifestation of negative emotions, aggression against those who do not seem likeable.

Correlation analysis has allowed determining significant relations between the indicators between the activity in social media and students' self-concept.

The "Material Self" indicator demonstrates the largest number of significant relationships with those indicators that reveal the specifics of activity on social media. This indicator is positively correlated with the indicator measuring the activity on social media ($r = 0.318$, $p \leq 0.05$), the indicator of communicative attractiveness of one's own account ($r = 0.319$, $p \leq 0.05$), the indicator of interest in obtaining information about other users ($r = 0.277$, $p \leq 0.05$). I.e., the greater the representation of qualities that reflect the possession of some objects, resources in the structure of self-concept of the college students, the more time they spend on social media, the higher their interest in finding information about friends is, the more followers they have on their personal pages (and vice versa). It can be assumed that the degree of manifested Material Self in the structure of self-concept mediates the relevance and ability to satisfy, through the

Internet, one's own interest in the resources and opportunities that others have and their preferences in implementing these resources. This interest is based on the mechanism of social comparison and supported by a focus on success attributes promoted by mass media.

The indicator "Communicative Self" is directly related to the indicator of social activity motivation on social media ($r = 0.33$, $p \leq 0.01$) and inversely related to the indicator "experience of loneliness in real life" ($r = -0.258$, $p \leq 0{,}05$) and "experience of loneliness on the Internet" ($r = -0504$, $p \leq 0.01$). I.e., the more qualities of an individual as a subject of communication are present in the structure of the students' self-image, the less frequently they highlight the experience of loneliness both in real life and in the virtual environment, and the stronger is the motive for taking part and supporting socially oriented projects, the more active the students are in supporting various actions initiated by other members of social media and aimed at providing assistance in finding missing people, helping to raise funds for those in need, etc. We can assume that social media act as a kind of platform for manifesting communicative activity on the one hand, and consolidating the related aspects of self-concept on the other hand.

The indicator "Prospective Self" is negatively interconnected with the indicator of openness on social media ($r = -0.33$, $p \leq 0.01$). I.e., the more characteristics are there in the structure of self-concept associated with plans for the future, the less open the person is, and the more likely he is to restrict access to its page.

Thus, it can be noted that the more interested the college students are in communicating, the greater the trend for defining and describing themselves through communicative qualities and qualities of possessing certain objects, the more frequently the young people turn to social media to fulfill their need for communicating and broadening social experience.

The data obtained in our study, reflecting the average time spent daily on social media by senior students of Russian schools, the characteristics of preferred activity on social media, such as focus on relaxation and communication are consistent with the data obtained in the studies by E.P. Belinskaya [23]. In general, it can be noted that today the Internet, and social media are a significant part of adolescents' life and an important condition for socializing and getting adult.

At the same time, the participants in our study demonstrated a lower willingness to transfer virtual acquaintances into real relationships, in comparison with the data obtained by E.P. Belinskaya [23].

5 Conclusions

The study of the special features of self-concept of the college students showed that "Active Self" and "Reflective Self" are the most represented components in the structure of self-concept, which is associated with the desire of young people to realize their place and purpose in life, and with actualization of ideas about their own uniqueness and potential. The gender specifics of the structure of self-concept was studied and it reflects a trend for polarizing the image of oneself, given the gender norms and stereotypes that young people have in the socialization process and during professional development.

The respondents rarely experiment with their own identities, and are careful in disclose personal information. However, students are familiar with the phenomenon of cyberbullying, have faced with rudeness on the Internet. There is evidence that girls experienced cyberbullying on social media more often than the boys.

Summing everything up, it can be stated that self-concept plays an essential role in identifying a pattern of social networking in the college students. Realization of the need for communication and expansion of social experience through social networks is mediated by such aspects of self-concept as Communicative Self, Material Self, and Prospective Self.

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Educational Design Patterns for Student-Centered 21^{st} Century Learning in Technology-Enhanced Learning Environments

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Abstract. Learners of the 21^{st} century face new challenges posed by the requirements of the digital era. However, education itself does not seem to have changed significantly. Thus, reports of a gap between graduates' competences and the skills truly needed in professional life accumulate. This paper proposes three best practices to modern 21^{st} century education formalized as educational design patterns. Relevant literature is reviewed and the used pattern mining process is outlined. Furthermore, three educational software services fostering the application of the proposed patterns are introduced and evaluated within the scope of usability tests with 56 secondary-level students and a focus group of three teachers. The results show that the educational software services are well suited to reasonably support class and the educational design patterns provide educators with field-tested best practices for 21^{st} century education.

Keywords: 21^{st} century skills · Student-centered learning · Educational design patterns

1 Introduction

The skills required to succeed in professional life have tremendously changed over the past decades due to the transition from a production-oriented industrial age to an information- and knowledge-based era. The theory on these novel skills required to be taught in modern 21^{st} century learning has been widely established [1–4]. However, the practical implementation as well as the integration of these 21^{st} century skills into the curriculum of educational facilities often seem to be insufficient [5]. Hence, researchers identified a gap between the competences acquired at educational institutions and the skills truly needed in the business

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sector [6–8], which could be a consequence of an overestimation of subject-related knowledge and the resulting negligence of social and personal competences at schools and universities. Therefore, a need for feasible educational strategies and best practices to integrate the development of 21^{st} century skills into teaching practice without the loss of subject-specific learning outcomes arises.

This paper introduces three best practices for student-centered learning in accordance with the requirements of 21^{st} century education. These best practices are generalized from previous work in the field of student-centered computer science education and are formalized as educational design patterns. To demonstrate their practical application, the results of a case study exemplifying their integration in technology-enhanced learning environments using three web-based educational software services are presented. The educational design patterns are designed to be modularly usable by researchers and practitioners aiming to apply student-centered principles to modern 21^{st} century education.

2 Related Work

2.1 21^{st} Century Education

Trilling and Fadel explored the new requirements for education posed by the 21^{st} century and developed a framework for 21^{st} century learning [1]. They identified a 21^{st} century skills gap and cited a study conducted in the business sector [9], summarizing the opinion of more than 400 employers. They conclude that graduates severely lack in several basic and applied skills, including communication, critical thinking, professionalism, work ethic, teamwork, collaboration, working in diverse teams, applying technology, leadership, and project management.

This finding corresponds to the work of Sin and Neave [8]. They extensively reviewed existing literature concerning the European Bologna Process, which aimed to improve graduates' employability. They found that employers did not see academic achievement as a sufficient indicator of an individual's employability. This is in accordance with the results of a large-scale study conducted among more than 1,200 professionals by van Laar et al. [4], in which the level of education was not significantly linked to nine of ten investigated 21^{st} century digital skills. Reasons for this could be a reported lacking integration of 21^{st} century competences in the curriculum and assessment, a missing strategy to adopt innovative teaching and learning practices, and insufficient preparation of teachers [5], which highlights the need for best practices in this field.

2.2 Student-Centered Learning

Van Laar et al. discovered a significant positive correlation between the attribute self-directed learning and five of the ten analyzed 21^{st} century digital skills [4], including information management and evaluation, communication, collaboration, and problem solving. Student-centered approaches and learner-centered methods typically rely on self-directed learning and were found to facilitate the development of 21^{st} century skills [10–12]. Trilling's and Fadel's recommendation for educational facilities transitioning to 21^{st} century learning is spending about half of the class time on student-centered activities like inquiry, design, as well as collaborative project work, and the other half on traditional and direct methods of instruction [1]. This corresponds to the findings of Case, who suggested to employ a combination of traditional and student-centered approaches [13]. Carl Rogers, who is seen as the originator of person-centered learning [14,15], shared his thoughts on education in the modern world:

"The only man who is educated is the man who has learned how to learn; the man who has learned how to adapt and change; the man who has realized that no knowledge is secure, that only the process of seeking knowledge gives a basis for security. Changingness, a reliance on process rather than upon static knowledge, is the only thing that makes any sense as a goal for education in the modern world." [16].

Hence, Rogers realized the superiority of the learning process itself over static knowledge more than 50 years ago. Freiberg added his findings to Rogers' work and criticized the apparent common belief that "higher-level and critical thinking skills will emerge from academic rigor" [17]. As a result of the prospective positive effects of student-centered learning, current research investigates the application of learner-centered methods to computer science education and technology-enhanced learning environments [18–23].

2.3 Educational Design Patterns

In computer science, best practices are typically generalized and described in the form of design patterns. Originating from Alexander's work in architecture [24], patterns found their entrance not only into the domain analysis [25] and design phase [26], but also into pedagogy [27] and student-centered learning. Derntl defined patterns for person-centered e-learning based on his research [28], defining a total of 52 patterns. Standl constructed a network of 24 interconnected pedagogical patterns for person-centered computer science education at the secondary school level [29]. Derntl and Standl both followed an iterative pattern mining approach – while Derntl used action research cycles comprising the five phases diagnosing, action planning, action taking, evaluation, and specifying learning, Standl followed a pattern development process consisting of three steps: scenario development, scenario testing, and pattern creation.

Both approaches and pattern catalogs provide useful and reusable best practices to student-centered education. Yet, Derntl's and Standl's patterns were modeled at a high level of abstraction. Based on Derntl's and Standl's work, this paper proposes three specialized design patterns, which were not completely encompassed by Derntl's and Standl's work. The patterns of this contribution specifically aim to foster 21^{st} century skills embedded in technology-enhanced learning environments for computer science education. Furthermore, three software services facilitating these patterns are introduced and evaluated. Therefore, the following research questions are addressed in this contribution:

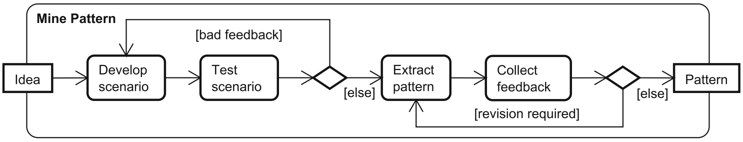

Fig. 1. Activity diagram of pattern mining process

RQ 1: Which reusable educational design patterns for student-centered 21^{st} century education can be generalized as best practices from the literature?
RQ 2: How can these design patterns be reasonably supported in a technology-enhanced learning environment through web-based educational software services?
RQ 3: Are students satisfied with the introduced software services?

3 Methodology

3.1 Pattern Mining

The used pattern mining process is practice-based and an extension of Standl's approach [29], as depicted in the activity diagram shown in Fig. 1. At the beginning of the pattern mining process stands an idea for a new approach to teaching. This could be a concept for an innovative lesson sequence, a new course type, or even a new way of organizing classes. An idea may emerge from reviewing relevant literature, own experience, or exchanging views with colleagues. Based on the initial idea, a plan for a scenario realizing this idea is developed. This process can be iterative itself by including other educators into the scenario development. The result of this phase could be for example a lesson plan, a course description, or a new organizational concept.

As soon as the scenario is found to be well-developed, it is applied and tested in the field. For instance, a lesson sequence could be performed or a course could be held. In this phase, data can be collected either qualitatively, in discussions for instance, or quantitatively, such as in surveys. If students' or teachers' feedback on the new scenario is not good enough or it is found to be impracticable, the scenario needs to be refined and retested. Given the scenario was found feasible and the stakeholders responded well to it, the pattern extraction process starts. The scenario, which is specific to a certain situation, is generalized and modeled using a common pattern template. Similar to related work [24–26,28,29], each pattern is defined according to the following key elements: pattern name, intent, motivation, structure, and effect category. The effect categorization, which is an extension of related approaches, comprises three groups and provides information on a pattern's dimension of effect: Activity patterns are small-scaled best practices, which can be easily integrated in a course. Course type patterns regulate the structure of a course, while organizational patterns imply an impact on an educational facility's organizational level and may encompass multiple courses. The three patterns proposed in this paper were developed using the described process and selected to exemplify one pattern of each effect category.

3.2 Development of Educational Software Services

The software services were developed using a human-centered design approach by including teachers and students in the design process, regularly inviting participants to test the current prototype and collect feedback. Final usability tests with subsequent interviews and surveys have been carried out with three cohorts and a total of 56 secondary-level students as well as one teacher to test the Peer Review Service and the Collaboration Platform. Furthermore, an expert interview was conducted in a focus group of three teachers to evaluate the usefulness of these two services. The interview was moderated by the developer of the system to study teachers' opinion on the educational software services.

4 Educational Design Patterns

4.1 Learning Office Approach (Organizational Type Pattern)

Intent: Provide a possibly schoolwide structure allowing for flexible class schedules as well as courses spanning across cohorts, grades, and school subjects.

Motivation: Learning office students have a flexible course schedule allowing them to choose the subject they want to progress in at a school day, facilitating individualization and differentiation. By being self-responsible for their own learning process, students acquire personal and interpersonal competences. Students of different cohorts and multiple grades study self-explanatory educational material in the same classroom and are coached by the facilitators, as indicated in Fig. 2. Advanced students may take extracurricular courses of higher grades. This also applies to students repeating a school year, who also benefit from being exempted from courses they already passed. This pattern is based on Rasfeld's concept [30,31] and was extended to computing education [11,12,22,23,32].

Structure:

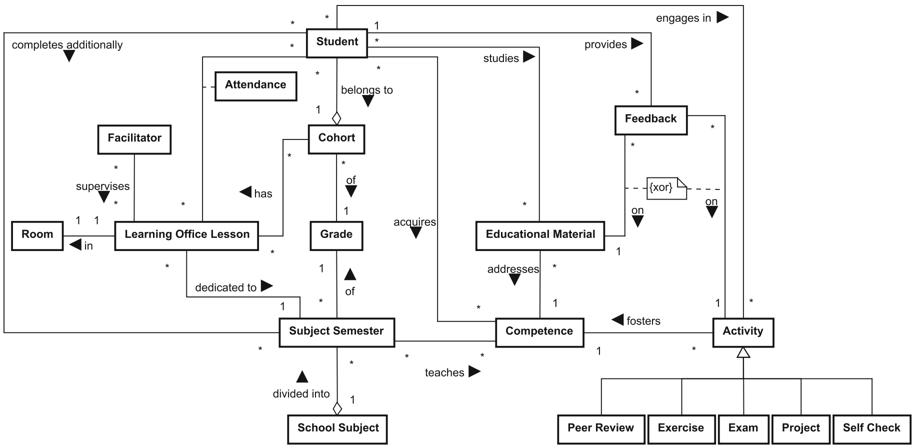

Fig. 2. Class diagram of educational design pattern "Learning Office"

4.2 Project-Based Course (Course Type Pattern)

Intent: Define a course structure optimized to support students in project work.

Motivation: The core of this pattern is working in groups on projects to foster students' life and career skills by simulating real-life scenarios in which students realize projects for a customer, impersonated by their advisor (see Fig. 3). The role of the facilitator is therefore twofold: He or she not only advises and coaches the project group as facilitator, but also slips into the role of the customer.

Structure:

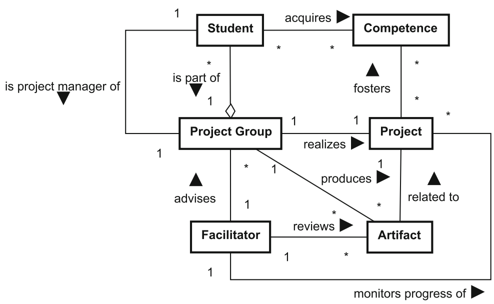

Fig. 3. Class diagram of educational design pattern "Project-Based Course"

4.3 Asynchronous Peer Review (Activity Pattern)

Intent: Enable time-independent peer review among students.

Motivation: The asynchronous peer review pattern is an extension of the peer check [29] and peer-evaluation pattern [28] to reasonably support courses allowing individual progression. Instead of a hard deadline after which the peer review is conducted, students may submit their work in the current review cycle. As soon as the required number of students submitted in the current cycle, the reviews are carried out according to the defined criteria, as shown in Fig. 4.

Structure:

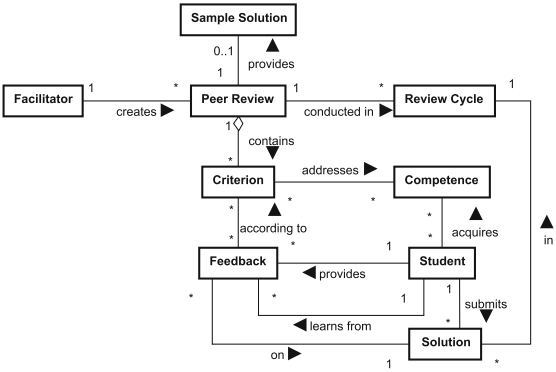

Fig. 4. Class diagram of educational design pattern “Asynchronous Peer Review”

5 Educational Software Services

5.1 Student Registration Management System

This software service supports the organizational pattern *Learning Office Approach*. Since students may choose between different subjects located in different classrooms, attendance cannot be feasibly captured using typical class registers or commonly used automated systems. The Student Registration Management System allows teachers of a learning office to track which students were present during a lesson. Up till now, this needed to be done by the facilitator using the web interface shown in Fig. 5 (left): Students would indicate their presence on a physical list of attendance, which was then entered into the web interface by the facilitator. This educational software service has been in productive use for four years and has undergone multiple iterations of user feedback and refinement, constantly adapting the system to users’ needs. The teachers of 13 of the 19 cohorts use the Student Registration Management System to administer registrations. Teachers’ feedback has been positive throughout; a formal benchmark of the system will be conducted in the future. This educational software service has been implemented using Django, PostgreSQL, Bootstrap, and JavaScript.

Since manually capturing and checking the names of tens of students in the web interface multiple times a day is time-expensive and error-prone, a prototype of a self-registration system was developed during the summer term 2020, as indicated in Fig. 5 (right). The learners may use their student cards to register for a lesson using a standalone Raspberry Pi interface connected to an RFID-reader, which is located in the respective classroom they want to register in. Assuming that manually tracking the attendance takes about 10 min per lesson block, a facilitator teaching 6 lesson blocks per week could save up to one hour per week, which he or she could spend coaching the learners. Due to the SARS-CoV-2 outbreak, the deployment of the prototype had to be postponed, which is why an evaluation of the system was not yet possible.

5.2 Collaboration Platform

The Collaboration Platform [33] supports students in their project work by offering them a common space for communication and organization without

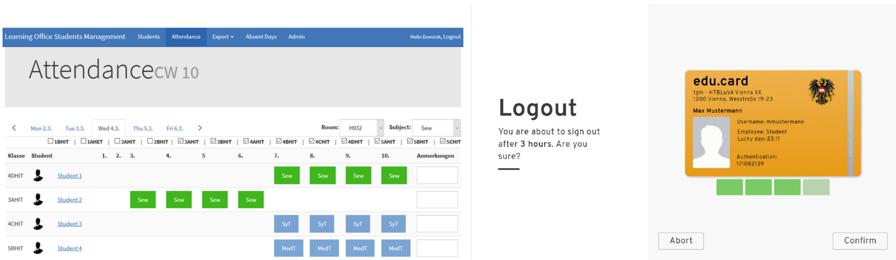

Fig. 5. Educational software service “Student Registration Management System”

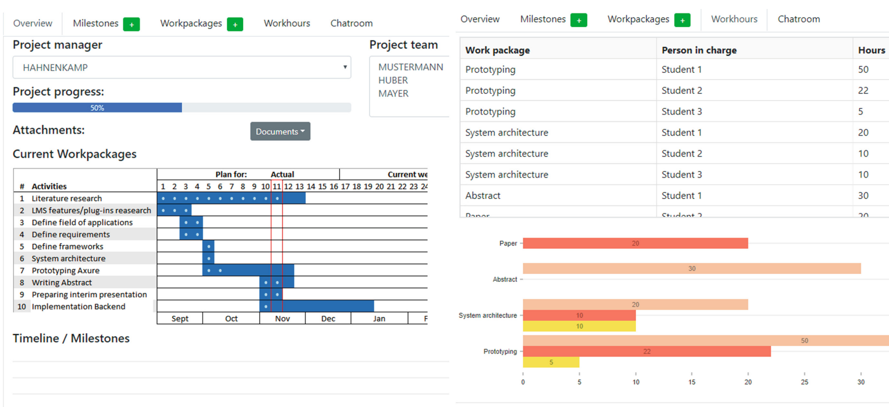

Fig. 6. Educational software service “Collaboration Platform” [33]

burdening students with the effort of becoming acquainted with complex collaborative working environments like Jira. It therefore facilitates the application of the *Project-Based Course* pattern. Students of the same project team can easily and intuitively share documents, define tasks, track their working hours, define milestones, update and monitor the progress of tasks and the whole project, and communicate with each other. Figure 6 shows the overview page of a project (left), including a project bar chart, as well as the overview of the working hours view (right). The Collaboration Platform as well as the Peer Review Service have been developed in ASP.NET, Microsoft SQL, React, and JavaScript.

5.3 Peer Review Service

The Peer Review Service facilitates the conduction of flexible web-based peer reviews and thus supports the application of the *Asynchronous Peer Review* pattern; details on the service can be found in [33]. The system allows teachers to define new peer review assignments including its evaluation criteria and to assign reviewers to each student. Students may upload their solution for the assignment and review each other, providing the possibility to give feedback to the work of others. Figure 7 shows the overview board of the current reviews (left) as well as the details of a peer review assignment (right).

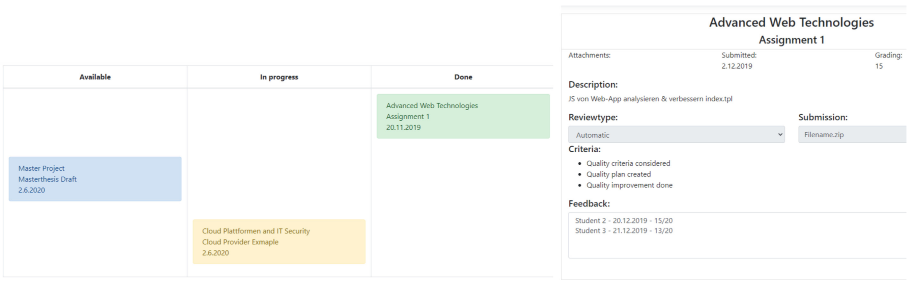

Fig. 7. Educational software service “Peer Review Service” [33]

5.4 Evaluation

The Collaboration Platform was tested together with the Peer Review Service by three cohorts and a total of 56 secondary-level students as well as one teacher within the scope of a usability test [33]. The feedback of students and teachers was extraordinarily good, resulting in a System Usability Scale (SUS) [34] score of 75 for both services, which generally indicates good usability. The task success rate of students was 100%: All students were able to solve all 15 tasks asking them to perform the core use cases of both services. Students' feedback on the system can be seen in Table 1. The statements 1 and 2 addressed both educational software services, while statement 3 is specific to the Collaboration Platform and statements 4–8 concern the Peer Review Service. Students perceived the system very well: Nearly all students stated that they were satisfied with the handling of the system, see the system as well-suited for supporting class, and think that it helps manage and realize projects. The feedback on the Peer Review Service was also very positive and highlight that students take giving feedback to peers seriously.

Table 1. Students' feedback on Collaboration Platform and Peer Review Service [33]

Statement	Rating					Mean
	(1) Strongly agree	(2)	(3)	(4)	(5) Strongly disagree	
1. I was satisfied with the handling of the system[a]	43	11	2			1.27
2. I think the system is well-suited for supporting class	49	5	2			1.16
3. The system helps to transparently manage and realize projects	47	7	2			1.28
4. I was satisfied with the received feedback	15	31	9	1		1.93
5. The system motivates me to give other students feedback	3	34	16	2	1	2.36
6. The received feedback helped me improve my submission	9	15	29	3		2.46
7. The received feedback helped me understand my mistakes	6	41	6	1	2	2.14
8. I tried to give honest and helpful feedback	50	4			2	1.21

[a] All statements were translated from German

The teacher was able to solve all three tasks of the Collaboration platform, but needed assistance during two of the nine tasks of the peer review system, resulting in an overall task success rate of 83%. The conducted focus group with the three teachers revealed that teachers see the Collaboration Platform as a useful tool reasonably supporting students in their project work. All three teachers saw both software services as valuable tools; one of them even stated that these services could replace current classroom practices to improve efficiency.

6 Conclusion

The proposed process provides a formal approach to mine patterns on three different levels: activity patterns, course type patterns, and organizational patterns. The three introduced educational design patterns exemplify the results of this process and capture strategies and methods of learning facilitating 21^{st} century education, allowing students to engagingly acquire essential social and personal competences required in the modern digital and knowledge-based age.

The implemented educational software services demonstrate how these design patterns can be successfully applied in technology-enhanced learning environments.

The results of the evaluation highlight the usefulness of the implemented software services and the educational patterns provide educators and researchers a reusable repository of approaches to 21^{st} century learning. Future work includes refining these patterns as well as the development of additional educational design patterns and software services supporting students in self-directed learning to give educational institutions useful tools to adopt to the new challenges posed by the 21^{st} century.

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A Comparative Study on the Environmental Behavior of Engineering Students

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Abstract. UNESCO documents state that Action for Climate Empowerment is implemented through education which has a crucial role to play in climate change, building capacities and attitudes for climate change mitigation as well as stimulating and reinforcing understanding of, and attentiveness of climate change. A particular attention should be paid to engineering programmes as engineers contribute to building a sustainable society, present and future, use resources efficiently and effectively, seek multiple views to solve sustainability challenges and manage risk to minimise adverse impact on people or environment. In turn, mathematics is seen as an instrument for sustainable development.

In the light of the above considerations the purpose of the study is to find out the ways how the United Nations SDGs are being pursued in engineering education, courses on sustainable development at different Baltic Network in Agrometrics universities and theoretical or specialty subject providing information about a sustainable approach to the environment. To implement *Action for Climate Empowerment* through education, the purpose of the study is to assess the ecological intelligence of emerging engineering professionals and to identify measures taken daily by students to reduce the impact of CO_2 as well as to identify areas that should be given more attention in the intensive mathematics course to be developed by the universities of the Baltic Network in Agrometrics. Analysing students' personal contribution to emission reductions, they understand the harmful effects of CO_2 emissions on the atmosphere, but not all of surveyed approve of their personal contribution to reducing them.

Keywords: CO_2 impact · Ecological intelligence · Sustainable Development Goals

1 Context

The 17 Sustainable Development Goals (SDGs), together with 169 related goals to address urgent global challenges over the next 15 years, are included in the "2020 Agenda for Sustainable Development" [1], which was formally launched worldwide on 1 January 2016. To combat climate change and its effects, in accordance with target

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13.3 it is necessary to improve education, awareness-raising and the capacity of people and institutions [2].

Education, as an action to improve climate change, has a key role to play in building capacity and attitudes towards climate mitigation as well as stimulating and reinforcing understanding of, and attentiveness of climate change [3]. Education for sustainable development must contribute to the development of the knowledge, skills, understanding, values and activities needed to create a sustainable world that protects and preserves the environment, promotes social justice and promotes economic sustainability [4]. When learners are empowered with knowledge, critical reflection tools, and media literacy, they are better prepared to act and make changes for themselves and others around the world [5]. W. Louw (2013) stresses the importance of university "green curriculums" to show ways for becoming specialists how to be effective in implementing sustainability ideas [6]. It means that the study process should be focused on education promoting the development of socially active, responsible, leading and professionally competent specialist protecting positions of sustainable future.

Particular attention should be paid to engineering programs as well as to mathematics. Why? Engineers contribute to a sustainable society by promoting efficient and effective use of resources, seeking diverse perspectives to address sustainability issues, manage risks and reduce negative impacts on humans or the environment [7]. To achieve SDGs, engineers need to focus on consuming resources in a way that does not go beyond ecological limits [8]. In turn, mathematics is seen as an instrument for sustainable development, because in mathematical activities (counting, measurement and location), people are developing ways to effectively meet their needs, indicating a clear link between people and the environment [9]. Therefore, engineering study programs at the authors of this article are mathematics-intensive as mathematics is included in all study programs. According to the UNESCO, understanding mathematics as a human activity makes it possible to think about how it can either support or undermine sustainable development [9].

It is worth noting that the universities represented by the authors of this article are members of the Baltic Network in Agrometrics. International cooperation in research and development provide opportunities for the exploration, discussion and exchange of education ideas, analysis of common problems, implementations of European dimension in mathematics education.

Experience has shown that in all networked universities, mathematics studies are still based mainly on traditional teaching methods, which involve passing key concepts passively to students, focusing on problem-solving techniques. However, in the context of sustainable development mathematics studies at university must be more focused on analysing the problems at different scales, learning to think in longer term processes, planning resource recovery processes, etc.

The UNESCO programme "Teaching and Learning for a Sustainable Future" for the United Nations Decade of Education for Sustainable Development [10] includes four themes for educators including also higher education. The first theme relates to curriculum rationale touching global challenges. The second theme covers ways how the curriculum could be changed introducing such models as citizenship, health and consumer educations as well as teaching about sustainable futures across the curriculum. The third theme comprises the usage of contemporary issues and in nowadays situation 17 SDGs in concordance with the proclaimed challenges in WEF 2018 reports [11]. The fourth theme focuses on developing teaching/learning skills with interactive, reflection and outdoor methods.

In keeping with these principles, the Baltic Network in Agrometrics universities have started to implement Nordplus Higher Education project "Math application in the context of socio-economic environment" with aim to provide engineering students with an in-depth overview of mathematics as a tool for sustainable development, making evidence-based decisions making to act in a sustainable manner in all its aspects: social, economic and environmental; cultivate abilities to apply mathematical knowledge in modelling of real-life processes and phenomena as well as calculate, interpret and present results. As part of this project, the network's universities are jointly developing an intensive mathematics course that promotes an understanding of sustainable development, highlighting SDGs and comparing data by partner countries in a broad sense of challenges of environment and climate changes with a focus on less consumption, zero-waste movement, healthy lifestyle, increasing CO_2 impact etc.

In the light of the above considerations the purpose of the study is to find out the ways how the United Nations SDGs are being pursued in engineering education, courses on sustainable development at different Baltic Network in Agrometrics universities and theoretical or specialty subject providing information about a sustainable approach to the environment.

The purpose of the study is to assess the ecological intelligence of emerging engineering professionals and to identify measures taken daily by students to reduce the impact of CO_2 as well as to identify areas that should be given more attention in the intensive mathematics course to be developed by the universities of the Baltic Network in Agrometrics.

2 Materials and Methods

The problem has been approached by analysing and evaluating the scientific literature and a number of information sources to develop the methodological basis of research in connection with the UNs sustainable development goals, education for sustainable development, ecological literacy (ecological intelligence, green consumer behaviour), etc. The study includes several components that characterize environmental behaviour of engineering students: ecological intelligence [12], sustainable consumption [13], environmentally friendly transport, energy efficiency [14], sustainable lifestyle [15], sustainable living [16] etc.

The empirical part of the research is based on the survey on environmental behavior of engineering students at four universities of the Baltic Network in Agrometrics: Latvia University of Life Sciences and Technologies, Riga Technical University (Latvia), Estonian University of Life Sciences and Vytautas Magnus University (Lithuania).

A total of 233 students answered the questionnaire. The sample consisted of 172 students from Latvian (LV) universities, 44 students from Estonia (EE) and 17 students from Lithuania (LT). The participants of the study were students from different fields of study - Electronics and telecommunications, Forest engineering, Woodworking, Social sciences etc. The most respondents (48.9%) were first-year students (Table 1).

Table 1. Profile of the respondents in terms of course.

Course	Latvia	Estonia	Lithuania
1	13	99	2
2	10	50	5
3	5	12	2
4	5	9	1
5	3	1	0
Master studies	8	1	7

The questionnaire included different types of questions: (1) respondents were given several statements and asked to mark the correct option, (2) most of the answers to the questions were to be given by expressing approval or rejection on three types of four-step Likert scale, (3) open questions. The questionnaires are available at: https://www.iipc.lv/surv/index.php/834593 (in Latvian), https://www.iipc.lv/surv/index.php/762752/lang-et (in Estonian) and https://www.iipc.lv/surv/index.php/182691/lang-lt (in Lithuanian).

The study used the self-assessment method, which is recognized as the most powerful tool for understanding and improving the performance of higher education institutions. In order to make improvements and promote learning, self-assessment aims to identify strengths and weaknesses in own work or behavior [17].

3 Results and Discussion

The survey participants were asked if they are aware of the sustainable development goals (SDG). Participants could respond by choosing one of the options to respond to question (Fig. 1). 40.4% of all respondents have never heard of SDG. It is interesting, that the 51.7% of Latvian students have never heard of SDG and by contrast Estonian students are enough familiar with them. This can be explained by the fact that the field of study of most of Latvian respondents was Electronics and telecommunications, and of most Estonian respondents were Forest engineering and Woodworking.

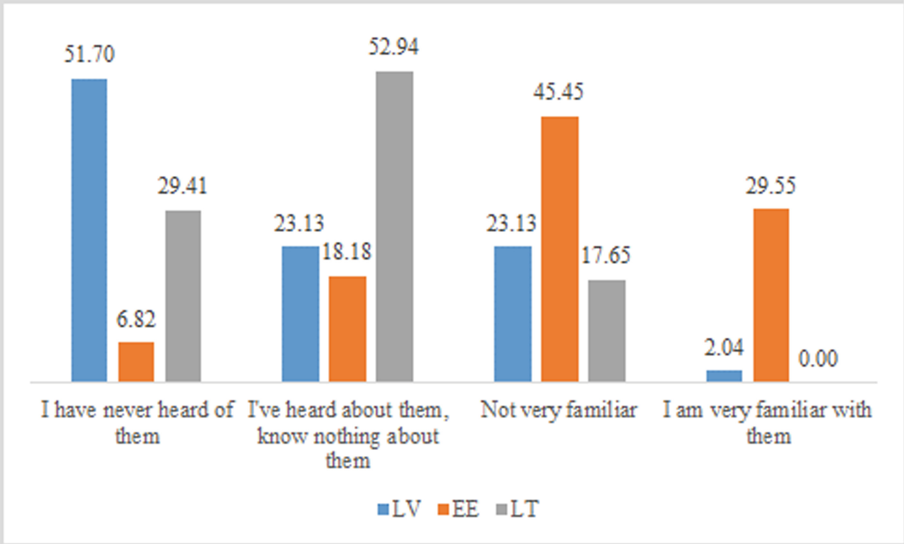

Fig. 1. Responses (in percent) to question "Are you Aware of the Sustainable Development Goals (SDG)?" (Source: own research).

The respondents were also asked about their ecological intelligence, skills to live healthier life, and promoting sustainable lifestyle.

Table 2 details survey responses. The majority of respondents felt that they have ecological intelligence. Also, the most of students from all countries indicate that they have skills to live a healthier life. When the subjects were asked about awareness of sustainable consumption, only Estonian respondents expressed strong support for this statement. About 50% of all students often use environmentally friendly transport. As can be seen, the majority of respondents highlighted that they are aware of energy efficiency. Only 34.1% of respondents answered "Yes" to the question "Do you promote sustainable lifestyle?".

Table 2. Survey responses (Source: own research).

Question	Country	Yes	Maybe	No	I don't know
Do you have ecological intelligence?	LV	42.86%	42.18%	7.48%	7.48%
	EE	70.45%	29.55%	0.00%	0.00%
	LT	70.59%	23.53%	5.88%	0.00%
Do you have skills to live a healthier life?	LV	72.11%	23.13%	2.04%	2.72%
	EE	58.14%	30.23%	6.98%	4.65%
	LT	62.50%	25.00%	6.25%	6.25%
Are you aware of sustainable consumption?	LV	37.41%	27.21%	25.85%	9.52%
	EE	90.91%	9.09%	0.00%	0.00%
	LT	46.67%	20.00%	26.67%	6.67%

(*continued*)

Table 2. (*continued*)

Question	Country	Yes	Maybe	No	I don't know
Do you often use environmentally friendly transport?	LV	44.90%	17.69%	34.01%	3.40%
	EE	38.64%	18.18%	43.18%	0.00%
	LT	57.14%	28.57%	14.29%	0.00%
Are you aware of energy efficiency?	LV	68.03%	16.33%	10.88%	4.76%
	EE	84.09%	11.36%	4.55%	0.00%
	LT	52.94%	11.76%	29.41%	5.88%
Do you promote sustainable lifestyle?	LV	31.97%	35.37%	25.17%	7.48%
	EE	38.64%	34.09%	18.18%	9.09%
	LT	41.18%	52.94%	5.88%	0.00%

Then, the respondents were asked if they have course/es on sustainable development in their university program. 84.1% of Estonian students, 34.3% of Latvian students and 31.3% of Lithuanian students answered "Yes". This difference can be explained by the fact that the respondents' fields of study are different.

Finally, students briefly reported in what theoretical or specialty subjects they get information about a sustainable approach to nature. Interestingly, that students mentioned not only traditional course such as Ecology, but also Business tax system (pollution tax), Energetics etc.

In the fifth question in the questionnaire, students had to assess their daily habits to reduce the impact of CO_2. They had to fill in the table with the following sub-topics: sustainable consumption, sustainable lifestyle, energy efficiency, hot water, zero-waste, and environmentally friendly transport. The table had a total of 18 questions. They could choose an answer from these four options: always, usually, seldom, and never. There were 44 responses from Estonia, 147 from Latvia, and 17 from Lithuania. The following can be highlighted from the three Baltic countries' replies (Fig. 2):

1) 46% of the respondents usually eat fruits, veggies, grains, and beans; 54% choose organic and local foods that are in season; and 37% reduce their food waste by planning meals ahead of time, freezing the excess and reusing leftovers. 37% of the respondents usually drive less: they walk, take public transportation, carpool, rideshare or bike to their destination when possible. If they must drive, they avoid unnecessary braking and acceleration.
2) 61% usually or always try to buy fewer things, and 73% of the students, who took part in the questionnaire, replied that they use a reusable bag in the store. 64% have changed incandescent light bulbs to LEDs, and 74% switch off lights when they leave the room and unplug electronic devices when these are not in use.
3) 42% of the respondents seldom buy foodstuffs in bulk, when possible use their own reusable container; 41% do not buy fast fashion, they buy vintage or recycled clothing; 37% wash their clothing in colder water; and 49% support or buy from companies that are environmentally responsible and sustainable. Also, students lower their thermostat in winter and raise it in summer. 29% use less air

conditioning in the summer, instead opt for fans, which require less electricity; 34% install a low-flow showerhead and take shorter showers; and 34% avoid flying, if possible, or take an economy class.

4) 28% never compost their food waste, if possible, 31% never turn their water heater down, 48% never do an energy audit of their home.

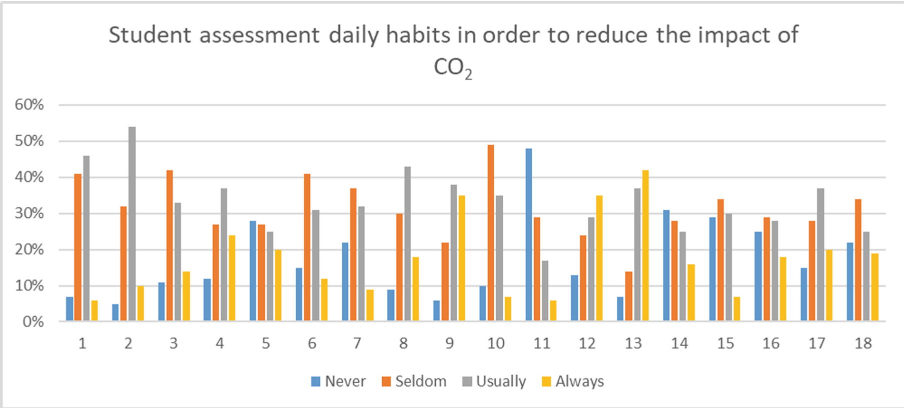

Fig. 2. Proportion of replies to all questions (In the graph the number corresponds to the question listed in Table 3).

Table 3. Proportions of the replies to the 5 question.

In the Fig. 1	Statements	Country	Always (%)	Usually (%)	Seldom (%)	Never (%)
Sustainable consumption						
3	Buy foodstuffs in bulk when possible using own reusable container	EE LV LT	11 15 18	39 29 53	45 44 18	5 12 12
6	Don't buy fast fashion. Buy vintage or recycled clothing	EE LV LT	9 14 0	20 33 47	55 37 41	16 16 12
8	Buy less stuff	EE LV LT	30 15 18	48 41 53	18 33 29	5 11 0
9	Bring your own reusable bag when you shop	EE LV LT	48 28 59	39 37 41	14 27 0	0 9 0
10	Support and buy from companies that are environmentally responsible and sustainable	EE LV LT	7 7 6	25 36 47	66 45 41	2 12 6
Sustainable lifestyle						
1	Eat low on the food chain. This means eating mostly fruits, veggies, grains, and beans	EE LV LT	5 5 18	55 41 65	41 44 18	0 10 0

(*continued*)

Table 3. (*continued*)

In the Fig. 1	Statements	Country	Always (%)	Usually (%)	Seldom (%)	Never (%)
2	Choose organic and local foods that are in season	EE LV LT	9 9 18	61 50 71	30 35 12	0 7 0
Energy efficiency						
11	Do an energy audit of your home	EE LV LT	5 5 12	9 20 12	23 31 35	64 44 41
12	Change incandescent light bulbs to light emitting diodes (LEDs)	EE LV LT	32 37 24	34 29 29	32 20 24	2 14 24
13	Switch lights off when leave the room and unplug electronic devices when they are not in use	EE LV LT	48 36 76	41 38 18	9 16 6	2 10 0
16	Lower your thermostat in winter and raise it in summer. Use less air conditioning in the summer…	EE LV LT	30 14 29	25 30 18	23 31 24	23 25 29
Hot water						
7	Wash your clothing in colder water	EE LV LT	9 7 18	36 31 35	41 36 35	14 26 12
14	Turn your water heater down	EE LV LT	20 14 24	32 24 24	27 28 29	20 35 24
15	Installing a low-flow showerhead. Taking shorter showers helps	EE LV LT	11 6 0	30 31 24	39 33 35	20 31 41
Zero-waste						
4	Reduce food waste by planning meals ahead of time, freezing the excess and reusing leftovers	EE LV LT	34 18 41	48 33 47	16 33 12	2 16 0
5	Compost food waste if possible	EE LV LT	43 14 12	20 27 18	18 28 41	18 31 29
Environmentally friendly transport						
17	Drive less. Walk, take public transportation, carpool, rideshare or bike to destination when possible	EE LV LT	27 16 29	39 37 29	25 29 29	9 17 12
18	Avoid flying if possible. Go economy class	EE LV LT	27 16 24	32 23 29	32 35 29	9 26 18

The following analysis was based on the proportions found, the analysis of variance, and assessing the differences between groups. Every group received a country selected, a specialty and a course. To do this, it was necessary to encode the replies to a numerical scale. The result of the dispersion analysis is mentioned when the comparison between groups revealed that the difference is important. If there is nothing written, the average between groups is equal.

The authors are mainly interested in how Estonian, Latvian, and Lithuanian students feel about their daily environment. Estonians (45%) and Latvians (37%) rarely buy bulk foods, whereas Lithuanians (53%) usually do purchase food in bulk (See Table 3). It is increasingly convenient to buy packaged food, but it is not environmentally friendly.

The analogous situation is with clothes. Most of the clothes that are sold in the shop belong to the fast fashion package. It attracts cheap prices, but there is no quality. You need to work hard to break this trend. It is necessary to strive towards better quality clothes, which means that it is necessary to break people's mind – every day there is no need to wear new clothes. The data shows that Estonians (55%) buy more rarely used clothes than Latvians and Lithuanians do.

We live in the world of things; our homes are filled with all sorts of gadgets. More environmentally friendly behavior would be to buy only the necessary things for yourself and take everything superfluous from your home away. The question "Buy less stuff" was answered always or usually by over 70% of Estonians and Lithuanians but only by 46% of Latvians. This means that Estonians and Lithuanians buy fewer things, which also came out as a significant difference in the 1-factor analysis of variance.

A similarly important difference was found with using a reusable bag when shopping. Estonians (always and usually 87%) and Lithuanians (100%) use it much more often than Latvians (54%). Estonian students (66%) seldom look at where the product is produced, it is not important that the product is from companies that are environmentally responsible and sustainable. Students in Latvia (37%) and Lithuania (41%) look at it much less seldom. At the same time, there are many students to whom the company's output they buy is important - Estonians (always or usually 32%), Latvians (36%) and Lithuanians (53%).

It is important for the environment to eat healthily while also sustainably. You should eat a lot of local food and then when it is time for the ripening of the vegetables or fruit. Based on 1-factor analysis of variance, it can be said that the dietary habits of Latvians and Lithuanians are significantly different. Lithuanians (always and usually 83%) certainly prefer to eat fruits and vegetables much more than Latvians (39%). Estonians' preferences (60%) are in between. Local foods that are in season are preferred by Lithuanians (89%), Estonians (70%) and Latvians (48%). There were no students from Estonia and Lithuania who does not eat fruits or vegetables, or who would not have a locally grown seasonal food to eat.

Energy audit is a concept of a recent time and it is seen that it has not yet become its own. Of course, it requires money and a lot of reconstructions at home to make the house energy sustainable. This is a question where students from every country replied the most that they had never dealt with it (Estonia 64%, Latvia 37%, Lithuania 41%). Students from all countries know that replacing a normal filament lamp with LED bulbs will help to save energy significantly (always and usually Estonia 66%, Latvia 55%, Lithuania 53%) and that it is useful to switch off the light when leaving the room (Estonia 89%, Latvia 62%, Lithuania 94%). Here the analysis of variance shows a significant difference between Latvia and Lithuania. This indicates that in Latvia switching off lights in a room has not become a habit. It is also known in all three countries that it is useful to turn the thermostat to lower temperatures in winter and to use less air conditioning in summer (always and usually Estonia 55%, Latvia 36%, Lithuania 47%), but at the same time, there are about one quarter of students who have never done it.

The study also shows students' water spending and its saving opportunities in three countries. Half of students never or seldom wash clothing in colder water when the rest have reduced the water temperature. Usually do this 36% of students from Estonia, 25% of students from Latvia and 35% of students from Lithuania. About the same situation is with temperature reduction of the water boiler. 20% Estonian students never do this, 29% Latvian and 24% Lithuanian students. Always do this 20% Estonian students, 11% Latvian students and 24% Lithuanian students. There is a big water saving when we use a low-flow shower and try to be there in the shortest possible time. From the table below we can see that option is not familiar to 20% Estonian students, 25% Latvian students and 41% Lithuanian students. For approximately one third of students of all three countries a low water spending is essential.

We save money and protect nature when we buy food exactly as much as we can consume. It also helps to save food by freezing it to be able to consume it at the right time. Most Estonian students (82%) and Lithuanian students (88%) do this always or usually but Latvian students (54%) do this usually or seldom, and 14% of students do not reduce food waste. When possible, one option is to compost food waste. Nowadays, there are separate waste bins for food waste near block of flats. Thus, in many cases, it is possible to collect food waste that goes to composting separately. 43% Estonian students always do this, 11% Latvian, and 12% Lithuanian. When doing an analysis of variance by country for these two questions, we found that composting is significantly different in Estonia and food waste is at a significantly lower level in Latvia.

Environmentally friendly transport is walking, taking public transportation, or riding a bike. We have seen how, during the Corona pandemic, the air became cleaner while people did not use their cars, stayed at home. Tartu is a small town in Estonia, here it is very convenient to move in the city by walking. Maybe that is why Estonian students walk always or usually in 66% cases when Latvian students do this 45% and Lithuanian students 58%. The data shows that there are also car lovers. 9% Estonian, 17% Latvian and 12% Lithuanian students do not agree to give up their car. Until recently, flying has been very popular, and the data shows that Estonians (59%) and Lithuanians (53%) have always preferred the economy class whereas for Latvians (61%) the economy class has seldom or never been important.

When comparing the differences between the study years using the analysis of variance, the only difference is found based on question "Reduce your food waste by planning meals ahead of time, freezing the excess and reusing leftovers" between 1st year students and the Master degree students, with Master degree students having more awareness.

4 Conclusions

There is a strong link between higher education and sustainability and the United Nations Sustainable Development Goals as higher education promotes learning and training in order to acquire and update skills, knowledge and competences, in turn the SDGs are a global framework to tackle common challenges for development.

The engineering degree programs of the above mentioned universities include various courses related to sustainable development. Information on sustainable and responsible attitude to the environment is also provided in some theoretical and specialty subjects.

According to several science-based studies, since the beginning of the industrial revolution, greenhouse gas emissions into the atmosphere have increased rapidly, mainly at the expense of CO_2 (carbon dioxide). Most respondents also understand this, pointing out that atmospheric pollution is very closely related to CO_2 emissions.

The survey looked at student's views on global warming and climate change, as well as possible solutions and changes in daily habits to reduce the negative climate impact. The vast majority of student responses indicate that global warming and climate change seem to them to be acute problems. Analysing students support and personal contribution to emission reductions, they understand the harmful effects of CO_2 emissions on the atmosphere, but not all of surveyed approve of their personal contribution to reducing them.

In terms of the reliability of the study results, some limitations have to be noted. First, the study required voluntary participation from the students. This might have caused positive involvement by the students who had already been interested in the field. Second, given the small sample size, this work should be seen as early findings to inform a future larger scale study.

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Professional Perceptions of Students of the Polytechnic University

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Abstract. The paper is devoted to the results of research into professional perceptions of students of the Polytechnic university in the context of their professional formation and self-determination. The first- and second-year students of the bachelor's degree program (60 people) took part in it. In the course of the research, the indicators of the level of formation of professional perceptions were studied. The most important factors that the respondents had in choosing a profession, the success of a future professional as well as their professional intentions were analyzed. At the initial stage of professional education, students' perceptions of their chosen profession are not filled with the subject content, are fragmented and limited. There are differences in the level and structural indicators of professional perceptions between men and women. Men's professional perceptions reflect a practically focused approach and an expressed desire to discover their own personality in their future professional activity. Women's professional perceptions have a pronounced emotional coloring and are oriented to the communicative side of their professional activity and their contribution to the public interest. The results of the research confirm the need for a targeted job to develop professional self-consciousness of the would-be specialist. In the curriculum, subjects can be distinguished, in the process of mastering which there is a targeted work on restructuring the perceptions of the chosen field of the professional activity. Such subjects may become a platform for monitoring, making it possible to track transformation of the system of professional perceptions and development of professional self-determination of would-be specialists.

Keywords: Professional self-determination · Professional perceptions · Levels of formation of professional perceptions

1 Context

Professional perceptions of a person are an important category in psychology. Nowadays, the problem of students' professional perceptions is especially relevant due to the rapid changes that take place in the world: different branches of science are changing, improving, old professions disappear and new ones appear. A typical situation is that of changing professions during a person's life pathway. Modern society,

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with its tendencies of constant development, moving forward, also dictates the need for a person to find their place in the world. This state of affairs, on the one hand, expands the scope of application of the competences received by a student in the course of education, on the other hand, creates great difficulties in coordinating the professional perceptions of a student and real working practice. Therefore, we believe that the work aimed at studying students' professional perceptions is relevant and practically focused. It will allow modernizing the educational process of the Polytechnic university, organizing purposeful work on increasing the level of formation of students' professional perceptions in the course of education. Moreover, dynamics of formation of professional perceptions can be a criterion for effectiveness of professional training and development of professional competence of would-be specialists.

2 Purpose

The purpose of the research was to study the professional perceptions of the first- and second-year students of the bachelor's degree program at the Polytechnic university.

Tasks of the research:

1. To identify diagnostic techniques for studying professional perceptions of students of the Polytechnic university.
2. To conduct an empirical study of students' perceptions of the most important factors in choosing a profession, the success of a future professional.
3. To study the level of formation of professional perceptions and professional intentions of students.
4. To carry out a comparative analysis of the studied indicators in men and women - students of the Polytechnic university.
5. To analyze the obtained results.

We have made an assumption that at the initial stage of education, average and low rates of formation of professional perceptions prevail among students. However, there are differences in structural and level indicators of professional perceptions between men and women.

3 Approach

A number of psychological and pedagogical studies are devoted to the problem of professional perceptions. Thus, V.N. Obnosov considered the dependence of professional self-determination on the perceptions of the future profession. [1, 2] Such authors as E.A. Klimov, B.F. Lomov, A.K. Markova, E.F. Zeer studied the relationship between professional perceptions and human development in the profession. [3–6] Professional perceptions as an important component of the personality image were also considered by E.I. Rogov, A.O. Antonova, I.G. Antipova, S.V. Zholudeva, M.V. Naumenko, I.A Pankratova, E.E. Rogova, N.E. Skrynnik, A.M. Sheveleva and E.A. Semenova [7–9].

Gradual formation of the professional identity in the consciousness of an individual was studied in the works by L.A. Golovey, L.I. Kuntz, N.S. Pryazhnikov, E.Yu. Pryazhnikova. [10–13] International studies of professional perceptions are described in the works by St. Avsec, Ag. Szewczyk-Zakrzewska, N.H. Choe, M. J. Borrego, M. Eliot, J. Turns, A. Godwin, G. Potvin, Z. Hazari, R. Lock in the context of career success [14–18].

In V.N. Obnosov's opinion, professional perceptions should be considered as an individual and peculiar system of knowledge, beliefs, and experiences of a person which are associated with a certain profession, i.e. "a totality of information available to a subject about a certain profession, his or her competence on the world of professions, their estimation according to the scale of prestige and attractiveness; this is a dynamic information entity, the structure and content of which depends on its intended purpose; this is a reflection of the human "Self" through a profession". [1] In V.N. Obnosov's opinion, the basis for the formation of an integral professional perception of a person is the moment of transforming an incomplete, poorly differentiated perception of the profession into its subjective personal model, the main feature of which is the filling of personal sensual experience. [2] Therefore, professional perceptions are strengthened and filled with a special meaning when a person becomes able to connect the image of their future activity with the character of their own experiences, with their unique personal characteristics, models of behavior in certain situations.

First of all, it should be noted that professional perceptions are manifested in the level of formation of professional identity in a particular profession. The professional identity can be changed not only in terms of its characteristics, but also entirely depending on whom or what a person associates this identity with. Many researchers in this field correlate the degree of success in formation of professional perceptions and further professional activity directly with the pace of a specialist's immersion in a profession, in practical activity.

The perception of the future professional activity of a student, according to E.A. Semenova, consists of three main interrelated components: the perception of the profession as a whole and of the personality of a professional; the perception of oneself as a would-be professional in the field; the perception of a possible professional future [9].

During their education at a higher education institution, students acquire competences as well as personality traits necessary for mastering and successful activity in their chosen profession. In the course of such transformations, both the value orientations of the student's personality and his or her vision of the surrounding world undergo changes. Thus, development of professionalism is inextricably linked with the personal changes of a student, which take place during the educational process (O.A. Andrienko, O.S. Zababurina, Yu.E. Schurova, G.S. Pomaz) [19–21].

In studies of university students' professional perceptions, stable images, which are the same for the representatives of a particular profession - the so-called invariants - are considered, and the image of the future profession is analyzed depending on the degree of mastery of the corresponding competences necessary for further work.

In addition to the knowledge, skills, and abilities necessary for successful activity in a given profession, professional perceptions also include emotional and sensory relations, motivational components and needs that arise in a person with the involvement in the given activity.

Depending on the degree to which students assimilate the above-listed components of the identity of the future profession's perceptions, different types of psychological readiness of students for future activities are considered. G.S. Pomaz, studying professional perceptions of students majoring psychology, has distinguished four main types of professional perception of students: "diffusive", "selfish", "incomplete", and "non-professional" [21].

Review of literary sources allows us to conclude that professional perceptions are an important part of a person's general idea of the surrounding reality and of themselves, they are individual for each person and simultaneously connect the person with the patterns of behavior adopted in society. Professional perceptions have a complex structure and are constantly changing depending on person's involvement in the profession. Professional perceptions of students are the foundation of future successful activity in the chosen professional field.

Research methods are the following: theoretical – overview of psychological and pedagogical literature; empirical – questionnaires, performance analysis, expert assessment, testing; methods of data processing – mathematical statistics methods.

Research methodologies: 1. Scale for assessing representations of D. Marx (methodology Directed at assessing representations of images of a future profession according to the criterion of "brightness - clarity") (modified version); 2. Test "Unfinished proposals" (modified version); [22] 3. Test "Professional intentions" by L. M. Fridman, T. A. Pushkina I.Y. Kaplunovich (modified version); [23] 4. Survey for evaluation of perceptions about the object of activity by E.I. Rogov [8].

The respondents were 60 first- and second-year students of Saint-Petersburg higher education institutions at the age from 18 to 20 years old. Among them, 34 were women and 26 were men.

4 Actual Outcomes

4.1 Research Results Based on Test "Unfinished Proposals" (Modified Version)

The analysis of experimental data allows us to conclude that the most significant factors in choosing a profession for students are positive emotional attitude to future activities (36%) and their own motivation to develop in the chosen area (36%). In addition, the ability to interact with people and the social utility of the profession play an important role in forming perceptions of the future profession (when describing the purpose of the activity, in particular, the respondents often used the words "help people") (32%). The main prerequisite for the success of a would-be professional in the chosen field was mentioned by the majority of the respondents as the need for internal motivation for self-development (69%). Assessing the qualities that contribute to the future job in the chosen profession, respondents mentioned: the level of mastering the necessary knowledge and skills, adequate self-assessment, level of motivation, stress tolerance, restraint, sustainability of the interest in the activity.

The analysis of gender differences shows that for women, the ability to actively communicate with people and the ability to discover and develop their own personal qualities play a more important role in evaluating professional choices. For men, in turn, the prestige of the profession and career opportunities are important. Women associate their success in the future professional activity more with the correspondence of the professional personality to requirements of the profession than men; factors of motivation, interest in the profession, and availability of knowledge and practical experience are approximately equally assessed by both sexes.

Respondents' answers indicate that the most important criteria of success in the profession for both sexes is the ability to realize their own potential and meet the requirements of the future profession. It was confirmed that professional perceptions are formed through the awareness of importance of the chosen profession for the society and require correlating themselves with the "benchmark" created in this field. In general, it can be concluded that these factors of correspondence of one's own personality to the future activity are the most important in forming professional perceptions.

4.2 Research Results Based Scale for Assessing Representations of D. Marx (Methodology Directed at Assessing Representations of Images of a Future Profession According to the Criterion of "Brightness - Clarity") (Modified Version)

A modified version of the methodology "Scale of perception evaluation" by D. Marks was used to evaluate representations of images of the future profession by the criterion of "brightness - clarity".

The sample under study is characterized by the prevalence of average and low level of brightness-clearness in perceptions about future professional activity. The perceptions concerning positive mood in the future work are the brightest and clearest. The weakest perception is that of the workplace and the content of a working day.

Table 1. Level of brightness and clarity of perceptions of the future profession among men and women

Indicator	General average score	Average score among women	Average score among men
Perception of the workplace	3.5	3.9	3.1
Perception of the content of a working day	3.5	3.7	3.2
Perception of the mood at work	3.8	3.7	3.8
Perception of future career plans	3.6	3.4	3.8

Dividing the respondents' answers by gender, it can be concluded that women have a clearer and more distinct perception of the workplace and the content of a working day, while men have a brighter and clearer idea of future career plans related to the chosen profession (Table 1).

In general, according to the obtained results, perceptions of future professional activity of the respondents are not filled with the subject content, are fragmented and limited.

4.3 Research Results Based on Test "Professional Intentions" by L.M. Fridman, T. A. Pushkina, I.Y. Kaplunovich (Modified Version)

Analyzing the professional intentions of students, it can be concluded that 42% of the respondents intend to work in the chosen occupation, 24% of the respondents have not decided on further plans in the professional field; 52% of the students do not consider their professional choice as final. Moreover, the percentage of the respondents who are confident in their final choice of a profession is higher among women; also, the percentage of those who intend to work in a different profession after completing their studies is lower among women. This may generally mean that women are more confident in their professional choice.

Among the ways to prepare for the future profession, the key proved to be acquisition of necessary skills and abilities (more pronounced among men) and development of personal qualities (more pronounced among women), and assessment of self-conformity to the model of a professional in the chosen field, both men and women, is most clearly manifested in the independent work. Lack of sustainable interest in professional activity was mentioned by the majority of the respondents as the reason why their own personality does not correspond to the idea of a successful professional. However, 11% of the respondents in general do not see any significant obstacles to become a successful professional in their chosen field.

Perceptions about conditions of a would-be job are generally blurred and inaccurate in the majority of the respondents (58%).

Based on the analysis of the data obtained, it can be concluded that confidence in the final choice of profession directly depends on the degree to which the perception of the future profession is formed.

4.4 Research Results Based on the Survey for Evaluation of Perceptions About the Object of Activity by E.I. Rogov

The survey for evaluation of perceptions about the object of activity by E.I. Rogov was used to describe the features of perceptions about the object of activity in a variety of ways.

Among the perceptions of the object of activity, the surveyed students in general distinguish individuals, groups of people, and society as key objects. This can be explained by the need for further work in teams, where relationships between people are essential for all activities. In the group of men, meanwhile, most of the students mentioned technical devices as the key object of future professional activity; in the group of women, interaction with people, groups of people, and society prevails.

The majority of respondents' perceptions of a would-be job are related to the ability to communicate with people and the requirement for a responsible approach to activities. Communicating with people is more important to women, while responsible work is prioritized by men. In addition, it is much more important for women than for men to be able to contribute to development of science, while men are more inclined to see a future job as a way of enjoying it.

Among the conditions conducive to professional excellence, the vast majority of the respondents of both sexes singled out professional qualities such as intelligence, persistence, and experience.

Both sexes highlighted a responsible and high-quality attitude towards the work performed as the main indicators of professionalism. It should also be added that, for women, the factors of the professional's compliance with the requirements of the profession and availability of knowledge, skills, and abilities are more indicative; for men, the ability to overcome obstacles, reputation, and experience.

Responsibility and understanding, patience and sustainability, perseverance and purposefulness were mentioned among the main qualities of the professional equally by both men and women. Thus, according to the majority of the respondents of both sexes, a professional is a person responsible for his/her actions, persevering in pursuit of the goal and having a high level of stability in behavior. In addition, for women, an important feature of a professional is sociability, responsiveness to others. This is also confirmed by the results of the Test "Unfinished proposals" (modified version).

The students surveyed, on average, have a positive perception of the object of their future activity, they are more aware of it as a bearer of socially important characteristics, but their professional perceptions are not clearly formed.

In women, perceptions of the object of their future activity are more connected with positive emotional assessment (the image is more joyful, pleasant, gentle, easy), while in men these perceptions are less positive but more accurate, realistic, and adequate (the image of the object of activity is characterized as more severe, hard, and complex but clear, accurate, active, and close).

Relying on the results of the analysis of the previous methods, it can be assumed that high emotional assessment of the future professional activity and the object of activity is associated with the possibility of the would-be professional to achieve those goals, which have already been identified and evaluated as particularly important for realization of self and personal development.

It can be stated, however, that the image of a future job is characterized by a lack of energy, initiative, and vigor. Women have much lower levels of activity than men in their future job.

Comparing the results of the four methods used in the study, we can conclude that the professional perceptions of the surveyed students in general are not fully formed both by the criterion of clarity and brightness, and by the criteria of accuracy, clearness, and closeness. Among women, important criteria in choosing a profession and evaluating its further success were those qualities related to interaction with people as well as the need to meet the requirements of the profession. Among men, the factors related to achieving material well-being and pleasure, developing creative and personal potential and gaining valuable experience in overcoming various obstacles dominate.

It is possible to assume that for women in forming professional perceptions, emotional factors and an external orientation of the activity are more important. For men, it is more important to have an accurate and clear understanding of what they will have to work with in the future and what they need to succeed - their activities are more focused on developing their own potential in order to obtain job satisfaction.

5 Conclusions

Today, due to the rapid constant progress in all spheres of activity, the problem of studying professional perceptions of students does not lose its relevance, but becomes more and more important. As professional perceptions, according to the majority of authors, are one of the key characteristics of the person in general, it is necessary to understand features of formation and development of perceptions for future professional activity, which is crucial for a deeper understanding of the person in general.

The results of the study allow us to conclude that the professional perceptions of students are not sufficiently formed, clear, and defined.

Men's professional perceptions reflect the practically focused approach and the expressed desire to develop their own personality in future professional activities. Women's professional perceptions, on the other hand, have a pronounced emotional coloring and are oriented to the communicative side of the professional activity and contribute to the public interest. Therefore, it is important to pay attention to these trends when forming clear professional perceptions in line with actual practice.

The professional benchmark is defined by most students quite unambiguously: a professional is an image of a person responsible for all his/her actions, capable of constant goal setting and perseverance in achieving the intended, having calmness, adequacy, and high stability in behavior.

During the initial stage of education, approximately a half of the students maintain a positive attitude and interest in the future profession.

Thus, universities should take into account, especially at the initial stages of education, the lack of clarity and accuracy of students' professional perceptions. In the curriculum, subjects can be distinguished, in the process of mastering which there is a targeted work on restructuring the perceptions of the chosen field of the professional activity. Such subjects may become a platform for monitoring, making it possible to track transformation in the system of professional perceptions and development of professional self-determination of would-be specialists. Besides, real professional experience contributes to clarification of professional perceptions. Students can gain this experience through practical training, which should be based on solving educational and professional tasks as early as in the first years of education.

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Poster: OER in Teaching Psychology and Pedagogy to Future Bachelors of the IT Sector

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Abstract. Exponential growth of innovations and the penetration of information technology into all spheres of life are actively increasing the demand for IT sector engineers and competences of graduates from university IT-courses. Key educational innovations in ICT include open educational resources (OER). It is important for IT sector engineers to master the skills of working with OER, which are a powerful tool for increasing learning possibilities and further education and training. However, little attention has been paid to using OER in face-to-face university courses.

The paper presents the findings form a research that was aimed at using OER in one-semester Psychology and Pedagogy course by undergraduate full-time students in Computer Science and Computer Engineering and System Analysis and Management at Kazan National Research Technological University.

Keywords: Open educational resources · Training engineers for the IT sector

1 Introduction

In a knowledge-based economy, the importance of open educational resources is increasing for an education system undergoing intensive informatization processes. The movement for open educational resources is based on the idea of openness, accessibility and free dissemination of information and knowledge.

The information society demands its members to be ready for lifelong education. In turn, technologies that penetrate into various spheres of human life substantially transform the educational environment and create new formats for the interaction of participants in the educational process, such as web 2.0 technologies.

OERs are an important instrument for the successful continuation of lifelong education enabling flexible adaptation to accelerating technological innovations. The importance of OER as a tool for self-education and lifelong education is increasing due to the dynamically changing requirements for competencies and skills presented by industry 4.0. In this regard, an understanding of the idea of open access and the acquisition of skills for creation and usage of OER are becoming relevant for both students and teachers.

The movement to spread OER in the global network has been on the agenda for two decades. The term “open educational resources” that was used for the first time in

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UNESCO documents in 2002, embraces educational and scientific resources on digital or any other media that allow free access, use and modification by third parties [1–3].

The following arguments are put forward in favor of this global initiative: OERs expand access to quality higher education and lifelong learning and contribute to improving the higher education system. The emergence of the technological ability to provide quick and free access to the educational resources of the world's best educational institutions has contributed to the idea that universities should open their collections of resources, and that governments should provide public access to educational resources created at the expense of the budget and introduce the necessary of this legislative norms. A call to governments for the promotion of OER and the use of open licenses as a means of ensuring equal access to knowledge was made at the Paris Declaration on OER, adopted at the 2012 World Congress on Open Educational Resources [3]. The further expansion of international practice related to OER was marked by the Second World Congress of OER, held in Ljubljana in 2017.

The unprecedented opportunities for an access to a variety of educational resources provided by the worldwide network have the reverse side of the difficulty of searching, selecting and assessing the quality of available resources, the number of which has reached enormous values and is constantly growing. With the rapid growth in the number of OERs available on the Internet, the role of universities as developers of OERs has significantly increased in connection with the requirements for their reliability and quality.

Meanwhile, not all freely available educational resources can be attributed as OER. Numerous resources on the Internet cannot be considered OER due to the licensing conditions. This is often the case since many authors of web resources do not apply to them free licenses because of a lack of knowledge about OER and copyright.

However, a study in which educators from different countries were interviewed revealed their misconceptions about OER. In particular, OERs are identified with any open access, excluding free licensing, as well as with MOOCs [4].

Therefore, it is noted that there is a "strong need for more dissemination of knowledge about OER and open licensing and their potential to transform education" [2, 5]. Alongside with knowledge, the importance of providing opportunities for training on searching, assembling and adapting OER is emphasized.

2 Theoretical Model to Form Readiness of Future IT Sector Bachelors to Use OER

A research was conducted aimed at using OER in one-semester Psychology and Pedagogy course by undergraduate full-time students in Computer Science and Computer Engineering and System Analysis and Management at Kazan National Research Technological University [6].

A theoretical model was developed and tested for the formation of the readiness of future bachelors of the IT sector to use open educational resources. It included methodology, content, process, and assessment blocks.

The ***methodology block*** of the model included the following *approaches*: constructivist (J. Piaget, L. Vygotsky); contextual (A. Verbitskii); web-based (D. Cormier,

G. Siemens, S. Downes); competency-based (I. Zimnyaya, E. Zeer, N. Kuzmina, D. Raven, V. Shadrikov, A. Khutorskoi and others); and the following *principles*: humanization; learning in an open, interactive, immersive environment [7]; professional orientation; taking into account the needs of students; self-realization through individual educational trajectories; dialogue and multichannel feedback; cooperation.

The ***content block*** of the model included the optional course "Open educational resources for learning in the digital environment"; a set of assignments, including authentic quasi-professional assignments, "reusable" [8] assignments, web-based assignments; and guidelines for the creation of OER with the use of open source software.

Specifically, in the part of the course devoted to open licensing issues, students were acquainted with the legal framework for open educational resources (OOR), which enables the OER movement. Students were taught that Creative Commons licenses provide legal and technical tools that educators and institutions use to share knowledge freely; Creative Commons provide six licensing options for derivative work and commercial use; Creative Commons provide tools that allow copyright holders to post their works in the public domain; Creative Commons provides a free online tool for choosing a license for creative works.

Students completed assignments for generating various Creative Commons license options on the service website. They also chose a Creative Commons license for video clips devoted to the issue of "Online-learning: Pro et Contra" they created in the video scribing technique. Assignments required to include into the video clips sources (text, audio, images or moving images) under different types of Creative Commons licenses, generate derivative works from sources used, determine the licensing requirements of the materials used in the video, specify in the video all rights related to the content used, and apply a Creative Commons license for derivative work.

The ***process block*** embraced methods, forms, and tools.

Methods included problem-based learning, Web 2.0 communications, individual creative web-based projects; collective web-based projects; web portfolio; mind mapping; video scribing; self-control and self-organization of educational activities.

Among *forms*, there were blended learning; online learning; "flipped" classroom; independent work on the implementation of individual creative web projects and collective web projects; e-portfolios; online consultations; internet forums; and chats.

Such *tools* were used as traditional and digital educational resources; educational online portals; software tools for interactive web portfolio; video scribing software; software for mind mapping; bibliography management software; software for infographics; software for animation; virtual labs; testing tools; Web 2.0 tools; LMS Moodle; electronic bulletin board; wiki technology.

The ***assessment block*** included description of cognitive, motivation and value, and technological components of the readiness to the OER use.

Indicators of the *cognitive component* are following:

understanding of the prospects for the use of OER in professional activities;
knowledge of the basic algorithms for searching OER in the network;
knowledge of open source software tools;

knowledge of open educational platforms, OER online psychology and pedagogy libraries, online courses in psychological and pedagogical disciplines hosted on leading Russian educational platforms;
knowledge of the methods and mechanisms for obtaining new knowledge through critical analysis and creative processing of OER;
knowledge of copyright protection issues in the digital world, licensing requirements for the use of OER and software products, free licenses.

Motivation and value component includes:

interest in using OER;
understanding of the importance of using OER in future professional activities;
the desire to achieve competence in the field of technology for working with OER;
awareness of responsibility for compliance with ethical and legal norms in the information environment, knowledge of how to respond to negative social behavior on the Internet [9].
Indicators of the *technological component* are following:
the ability to carry out an information search for open educational resources and identify them;
possession of technologies for the creation, recording, copying, replication, storage, processing, distribution, perception and exchange of OER;
skills of working with free access software;
possession of interaction technologies in a distributed network, methods for the joint production of knowledge, skills in using Web 2.0 technologies in the process of solving problems.
possession of the skills to manage their digital identity and personal data, information security technologies on the Internet.

3 Experiment on the Formation of Future IT Sector Bachelors' Readiness to Use OER

Applying the developed model to teaching future bachelors in Computer Science and Computer Engineering and System Analysis and Management Psychology and Pedagogy course resulted in students' better understanding of OER value for future professional practice.

Research of the model exploring effectiveness has shown that instructional and learning experiences based on selected approaches and methods helped increase students' engagement and positive attitude. It was revealed that instructors need new competences to teach students how to use OER, which include skills of assessing OER developed by students, psychometrics, and web-communications. Analysis of the qualitative and quantitative data indicated that the model explored in experimental Psychology and Pedagogy course delivery enhanced student learning. Students of the experimental group have shown a higher level of readiness for the usage of OER as compared to students of the control group. The diagram shows differences of the levels of the formation of cognitive, motivation, and value and technological components of readiness for the usage of OER between the students of the experimental (EG) and control groups (CG) at the beginning and end of the experiment (see Fig. 1).

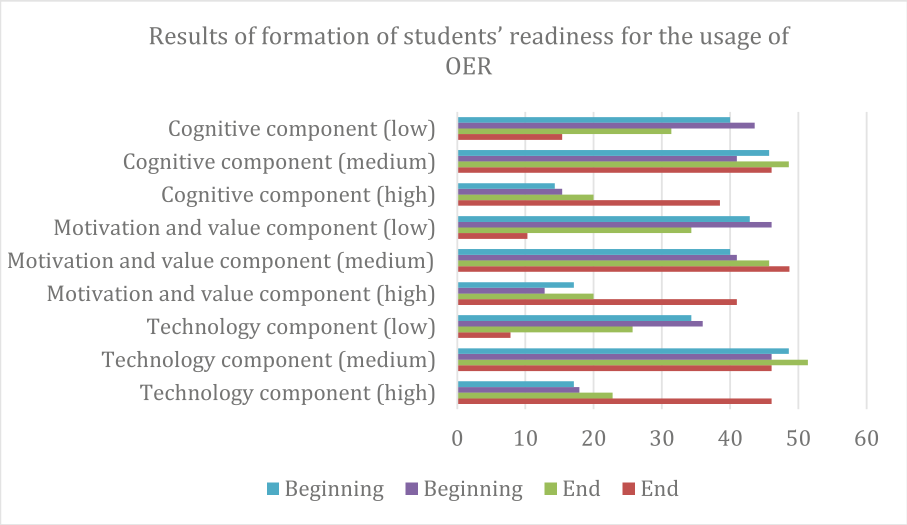

Fig. 1. Results of formation of students' readiness for the usage of OER

Analysis of the data using Fisher angular transformation co-efficient tests showed that the proportions of students of the experimental group who reached high levels exceeded the similar indicators of the control group for all the criteria: for the cognitive criterion $\varphi^*_{emp} = 1.77$, $p < 0.05$; for the motivational-value criterion $\varphi^*_{emp} = 1.99$, $p < 0.05$; for the technological criterion $\varphi^*_{emp} = 2.13$, $p < 0.05$.

Students of the experimental group showed as well a higher level of Psychology and Pedagogy knowledge and skills as compared to students of the control group ($p < 0.05$).

The present study provides evidence that the use of OER in face-to-face training of engineers for the IT sector might contribute to the students' obtaining meta-skills of continuing education that could be extended beyond the educational environment of the university.

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Teacher Readiness for Distance Learning

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Abstract. The article is devoted to the study of the readiness of teachers and students of an engineering university to implement distance learning in modern conditions. The study of the phenomenon of preparedness involves focusing on a number of problems, which are simultaneously factors that impede the formation of readiness. Both positive and negative aspects of the use of distance technologies were identified.

Keywords: Readiness · Distance learning · Teacher

1 Context

Informatization, as the leading trend in the socio-economic progress of developed countries, is an objective process in all spheres of human activity, including education. Computerization of education is a system of methods, processes and software and hardware integrated with the goal of collecting, processing, storage, dissemination and use of information in the interests of its consumers. The goal of informatization of education is the global intensification of intellectual activity through the use of new information technologies [1].

Modern conditions of the information society, the development of information infrastructure of universities require the inclusion of new approaches, methods and technologies in the educational process. The most important in this case is the development of cooperation - the most important component of the educational process - "teacher – student" - based on non-standard forms and methods of interaction, creating a scientific and methodological system of continuing education (both teacher and student) within a single educational space. The success of student training and education largely depends on how this tandem of cooperation develops, what forms and methods will be used in this case, on the basis of what modern technologies they will be built [2]. Accordingly, the use of distance education technology expands the possibilities of the teacher in terms of the humanization of education, modernizes the educational process, and makes it attractive to students.

Distance learning is recognized as a promising direction in the development of the modern education system, capable of solving a number of urgent problems of higher education. It does not deny existing educational trends and technologies, forms of

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training; it is designed to integrate into these systems, complementing and developing them.

The use of distance educational technologies, the practice of training on various online platforms within the framework of formal and non-formal education, the use of the Internet, e-mail and WhatsApp have long become commonplace in the process of obtaining knowledge when organizing the interaction of all subjects of educational activity [3].

However, the new reality that has hit the world in connection with the pandemic and the threat of the spread of COVID-19 has made it necessary to reconsider the potential of the distance learning technologies and electronic resources available to the educational community.

Life in a pandemic has made significant adjustments to education at all levels around the world. The educational process has completely switched to on-line format. The Russian educational system was no exception. Kazan National Research Technological University organized training using distance learning technologies and e-learning, using the MOODLE, ZOOM, Microsoft team, Skype, etc. platforms for this purpose. However, an analysis of the activities of teachers in the first week of the so-called distance learning showed that many teachers turned out to be they are not ready to fully utilize information technology training, despite the fact that they regularly improve their qualifications in this area. Teachers of engineering and humanitarian disciplines have differently assessed and responded to the difficulties of organizing the educational process in the new conditions. The electronic information educational environment, created taking into account the formal requirements of federal state educational standards, also turned out to be very weak help for promptly solving the issues of interaction between teachers, students and the university administration due to the inefficiency of this resource by objective and subjective standards.

Many Russian students were not prepared for such extraordinary innovations. The traditional paternalistic model of teacher-student relations in Russian universities, different from the Western highly individualized model, accustomed them to regular direct communication not only with teachers, but also with representatives of the administration. They have largely lost this opportunity. The educational process outside the framework of training has become almost impossible.

Finally, if online communication with friends for students has long become the norm, then to see a teacher in a home environment with a cat or a child, to show himself in the interior of his room and at the same time to watch a presentation on discipline on the screen of a gadget was often a very difficult task from the point of view view perception of information.

Distance learning is a revolutionary way to equip a student with the skills and knowledge necessary to turn changes in cognition into an advantage. Many teachers note that distance learning can be used as a knowledge management tool. It is suggested that synchronous tools need to be integrated into asynchronous environments to provide a learning model "anytime". This environment will be primarily asynchronous with background discussion, appointments, and evaluation occurring and managed with synchronous tools.

From the point of view of the engineering areas of training - distance education was a discovery - on the one hand, it was an opportunity to offload the teacher from intermediate tests of knowledge - by conducting testing on educational platforms. On the other hand, there is an urgent need for full-scale experiments, the absence of which leads to one-sided knowledge, since in the framework of engineering, chemical and chemical-technological areas of preparation it is impossible to do without theoretical knowledge, such as in the framework of fundamental disciplines (physics, mathematics) and general engineering disciplines (processes and apparatuses of chemical technology, engineering graphics).

In the future, the training, which will be carried out by classical methods and methods, will need to use the gained experience of distance educational technologies - conducting tests, creating electronic educational resources, conducting and recording copyright lectures, to advise students of distance learning and with disabilities on Moodle platforms, Google Meet, MS Teams, Zoom.

2 Purpose or Goal

In the last century, we moved from the industrial era through the information age, and now into the knowledge age. Today, the effective acquisition, storage of knowledge and its effective management are the key to success and survival for organizations in a very dynamic and competitive world. The ability to acquire, absorb and apply knowledge effectively will become a key skill in the 21st century. Learning is the key to unlocking a person's full potential.

Our life in the XXI century as an individual, a specialist, will depend on our ability to learn and apply what we know in our professional life. Training will become more integrated with work and will use a shorter, more modular, timely delivery of knowledge. Distance learning delivers knowledge through electronic information and communication technologies.

Information and communication technologies include various methods - a systematic feedback system, computer network operation, video conferencing and audio conferencing, global Internet sites and computer training. This way of delivering knowledge increases the possibilities of how, where and when students can engage in lifelong learning.

Distance learning is not only training and instruction, but it is focused on individuals, it is individual. A single definition for distance learning has not yet been identified. This includes online learning, including e-learning, online learning, distributed learning, online learning, virtual learning, computer learning.

Distance learning refers to the use of information and communication technology to improve and/or support learning in higher education.

Education systems around the world have taken steps to reduce the negative impact of the coronavirus pandemic (COVID-19) on education. An interactive mapping "Global monitoring of school closure in connection with the COVID-19 pandemic" is presented on the UNESCO website, which displays the development of the situation of closure of educational institutions in various countries, from February 8 to April 20, 2020. On April 20, 2020, 1,575,270,054 people studied remotely, which is 91.3% of the total number of students worldwide [4].

Therefore, distance learning is gaining more and more popularity. And this is not surprising, because you can remotely study in almost any subject.

By the term “distance learning” we mean learning, in which all or most of the training procedures are carried out using modern information and telecommunication technologies with the territorial disunity of the teacher and student [5]. It is important that the basis of distance learning is based on pedagogical technologies of different temp learning, independence in self-education of students in various educational fields, the possibility of choice, a combination of various forms and methods of interaction between the teacher and the student. It should be borne in mind that distance learning involves careful selection of educational material, its coordination with the educational standard of the educational content, and the multilevel structural organization of educational material. Distance learning as a system for organizing a focused process of interactive interaction between educators, students and teaching aids is presented in the aggregate of two basic subsystems, each of which consists of certain elements. The first and main is the didactic subsystem. It includes components typical of traditional learning. Its functioning is based on an ordered set of goals, functions, methods and techniques, principles, requirements and conditions for the effectiveness of their interaction, factors of influence on its effectiveness. The technologies prevailing in distance learning impose their restrictions on the selection, sequence and method of presenting fragments of the content of training. Each of these components in the distance learning system has its own specifics. It is distinguished by both the content of each of these components and the redistribution of their role and frequency of use in the educational process. In remote form, teaching by technical means becomes predominant, and the role of the teacher as a source of information is represented by the content of the options for training courses developed by him, as well as in informing the learner of information that goes beyond the scope of this course, or explaining fragments of texts and assignments that are not understood by the learner. The teacher’s activity in the educational process is transformed from the main to auxiliary, and the content of his activity is determined by the content of the student’s orders, formulated in the form of questions posed by him. This violates the integrity of the teacher’s activities, and the way the implementation of the analysis and planning functions characteristic of traditional teaching is fundamentally changed. Another task is subordinate to the planning of interaction with students in distance learning. For a relatively short time of telecommunication with the student, you need to answer his questions. The teacher’s activities are impromptu, which not every teacher can do and requires special training. The second component of the distance learning system is a technical system for ensuring the transmission of information, the implementation of monitoring and consulting functions. Unlike traditional learning, this subsystem is not auxiliary, but one of the central ones. It is represented by teaching aids specific to this didactic system, which, on the one hand, are printed materials and computer programs, and on the other, telecommunications. All these subsystems and their elements interact in the educational process in various ways, the choice of which depends on the goal set by the teacher and the learner, the technical means used and the model of training chosen by the teacher. This choice depends on the level and pace of progress of the student and can be offered to the teacher and the student himself. In this interaction, the functional purpose of the distance learning system is realized, interactive interaction of students and teachers in the learning process is provided, and students can work independently, evaluate their knowledge and skills. When in practice, the whole world began to use the Internet everywhere, disruptions in its functioning began, especially the students who live quite far from large cities.

In the distance learning model, the learner is at the center of the learning process; the essence of training is independent work developing self-learning abilities; the basis of educational activity is cooperation, and the role of students in learning is more active than the role of a teacher. In distance learning, the dominant tasks are the organization of an independent cognitive activity of a student, arming him with independent work skills to acquire new knowledge and their practical application.

Indeed, at present, in the informatization of education, it is becoming more and more relevant not so much the technical equipment of education as the readiness of all subjects of the educational process (in particular, teachers) to use distance educational technologies in their professional pedagogical activity [6].

The development of distance learning is hindered not because of an insufficient material and technical base or lack and imperfection of software, but because of the mismatch between the competences of using networks in students and the competencies of teachers, who use them to a lesser extent. Changed learning goals, living conditions and needs of the individual require the application in the shortest possible time of the entire set of tools for the full organization of the educational process. Therefore, it is necessary to determine the readiness of both teachers and students for a new type of training for them. Will it be able to realize all the didactic components of the educational process, will the methodology chosen by the teacher lead to the planned learning objectives?

A comprehensive analysis of the state of formation of the teacher's readiness for the use of distance educational technologies, as well as modern research on this topic allowed us to highlight a number of contradictions:

- between the presence of scientifically based approaches to the application of these technologies and the special educational needs of society during the pandemic (E. Segen, V.P. Kashchenko, T. Helbrüggge, A.Yu. Yusupov, etc.) and the insufficient awareness of teachers about all the possibilities her tools;
- between the accelerating process of development and implementation of distance technologies in education and the insufficient willingness of subjects of the educational process to constantly apply these technologies in their activities;

It must be borne in mind that the willingness to use distance technologies is formed in the process of professional and personal development of a teacher and it can be considered as a process and the result of becoming a person as a subject of professional activity. By readiness for the implementation of distance learning, we mean the stable integral dynamic quality of the teacher's personality, which determines the content, orientation and nature of her professional and pedagogical activity, as well as self-determination and self-realization.

3 Approach

Mankind has entered a new - information stage of its development, when information processes become one of the most important components of the life of a person and society.

The basis of the open education system is distance learning, the universality of which ensures the realization of the idea of lifelong education aimed at creating a personality with the necessary initial supply of intellectual forces and the ability to replenish them throughout the life course. Broad development only distance learning system will allow you to move from the concept of “education - for life” to the concept of “education - through life”.

The basis of distance education is e-learning - the most important mechanism and consequence of the transformation of the Internet. This training allows students to fruitfully collect information using both synchronous and asynchronous methodologies in order to efficiently and quickly acquire the latest knowledge.

Many authors (A.A. Andreev, V.P. Demkin, A.V. Khutorskoy et al.) Consider distance learning as a form (principle of organization) of education: a focused, organized learning process, focused on the formation of knowledge, skills defined by the curriculum and teacher. Many researchers identify distance learning as a means of learning management and the implementation of the learning process.

The questions of determining the essence of distance learning and distance learning technologies are the work of A. A. Andreev, E. S. Polat, I. V. Robert and others.

A. A. Andreev in his work as distance learning understands “a purposeful process of interactive interaction between learners and students with each other and with learning tools, invariant to their location in space and time, which is implemented in a specific didactic system.”

E. Polat gives the following definition of distance learning: “by distance learning we mean the interaction of teachers and students, students at a distance, reflecting all the components present in the educational process (goals, content, methods, organizational forms, teaching aids) using specific Internet tools - technologies or other interactive technologies” [7]. V.I. Ovsyannikov identifies distance learning with electronic (elearning), while the fastest implementation of proven technologies abroad is put in the first place.

According to L.I. Doliner, distance learning is a form of education (full-time, part-time, external), based on the use of new information technologies (computers, telecommunications, multimedia) and scientifically based methods learning.

The problem of the activities of distance learning teachers was highlighted in their works by E. Gavrilova, E. Haustova, L. Vasilchenko, N. Mulin and others. Foreign researchers Michael G. More, William G. Anderson, Gregory S. Sales and others also pay attention to this problem. Acquaintance with scientific research shows that the writers reflect the specifics of teaching activities, individual requirements for distance learning teachers. Despite the significant results of research in these areas, important aspects of the problem of the formation of professional readiness of higher school teachers to introduce distance educational technologies remain outside the field of view of scientists.

The success of the entire distance learning system ensures not only the teacher's readiness for professional and pedagogical activity in it, but also the building of different groups of relationships and interactions with subjects of educational relations in the new conditions of distance learning environment.

In the federal state educational standards 3+ +, the electronic information and educational environment is considered as a key element of the educational process, therefore, each student throughout the entire period of study should have individual unlimited access to these resources. For knowledge and information to be effective, it is necessary to constantly increase and modify it in continuous educational activity [8]. All these ideas can be implemented in a modern university, which is the Kazan National Research Technological University: innovative and commercial attractiveness, manifested in the fact that the university implements socially significant educational and research projects; research and fundamental orientation, involving the dissemination of scientific knowledge as an integral part of world culture; informational saturation of the educational process, the driving force of which is the electronic informational and educational environment of the university [9]. The training of a modern highly educated specialist is aimed not only at mastering knowledge, skills, but also at adapting to the conditions of future professional activity in society, including in a virtual environment.

However, the real permanent use of distance learning in the Russian educational system is practically absent. What is the reason? Distance learning consists of three main components: the technical aspect (computer technology), the teaching and methodological aspect (multimedia courses in disciplines) and the teachers who conduct activities in the distance learning mode.

There are more than a thousand computers at the university; electronic information and training programs in various disciplines have been developed (and continue to be developed), but the third element is practically absent, i.e. teachers who are able and ready to work professionally, psychologically and technically in the distance learning system.

According to the recommendations of UNESCO, a modern teacher should be able to select and use in their work software products and web resources in their subject; use search engines. Students' participation in e-learning courses involves diverse and intense conversational communication.

1. The design of educational programs in the distance learning system should be based on the principles and distinctive features of distance learning. The most important of them is the principle of distributed learning, when an open information system makes it possible to obtain knowledge from various information resources. Thus, distributed learning is a necessary element. The construction of distributed information systems is associated with the solution of a number of technical and technological problems and the availability of relevant specialists in the field of information and educational technologies.
2. The organization and implementation of the educational process of distance learning is based on the use of an information model in which means of remote access to information resources make it possible to build an individual educational trajectory based on independent work of students. You must be familiar with the

methods of developing and creating interactive training programs, implementing distance learning technologies and forms of organization of the educational process.
3. Achievement of educational goals is a necessary condition for the quality of education. The development of personal characteristics, professional knowledge and skills is determined by a number of indicators that make up the general level of educational effects. Achieving such indicators requires knowledge and consideration of the psychophysiological and biomedical features of distance learning, the ability to use modern tools and methods for monitoring the quality of education.

In the process of distance learning, the role of the teacher changes: he designs not only the educational process, but also the network interaction with students; forms the environment of distance learning, developing teaching materials, manages joint distance learning activities, mobile adjusting it to the changing educational needs of students. His activity is multidimensional, different in the implementation of traditional training.

In the face of the threat of the spread of coronavirus infection, most universities and colleges, on the recommendation of the Ministry of Science and Higher Education of the Russian Federation, decided to switch to distance learning.

In this regard, all full-time classes, including lectures, practical and even laboratory ones with virtual analogues, were transferred to the online environment.

Teachers are forced to organize the educational process through distance learning technologies based on various methods of delivering electronic content and accessible communication tools for students and teachers in the electronic information and educational environment.

The transition to distance learning was not a planned action, but a necessary measure, so the teachers did not have special training. The teachers did not have enough skills in the digital environment, time to master new tools and restructure the educational process and support from the technical services of the university, which play an important role in the implementation of new technologies.

The adaptation of teachers to the changing conditions of professional activity occurs at different speeds and with different results. But it must be recognized that the possession of competencies in the field of working with information resources helps them more easily switch to a new training format.

New challenges expand and give the university teacher new tasks of professional pedagogical activity:

"See" each student, determine his goals, tasks in a distance educational environment;
build the educational process in an interactive, productive, time and space invariant process of interaction with all subjects.

As a result of the transition to distance learning, organizational, methodological, and psychological difficulties appeared before the university teacher.

Organizational difficulties are associated with taking personal responsibility for the implementation of the learning process in the new conditions, relying on clear and accessible tools for each teacher.

Methodological difficulties include the difficulty of controlling knowledge. Reproductive tasks are not suitable in these conditions. It is necessary to apply creative, productive tasks. It is necessary for the student to create something: a project, a drawing, and complete a creative task. The deficit of feedback can be compensated by a multimedia format, communication in social networks. The authors really like the What's App network, where you can organize substantive communication and the teacher can be poisoned with completed tasks as well as ask personal questions.

Psychological difficulties are determined by the experience of uncertainty, "digital overload", anxiety in the situation of video recording, associated with the possibility of posting materials in a collective access. The teacher does not feel the person in the audience, does not see his reaction.

4 Results

The evolution of distance learning offers a large number of tools to help the teacher in the process of analysis, design, implementation and delivery of knowledge via the Internet. In the framework of distance educational technologies, the question arose about the lack of time for both the teacher and students, since everyone is within the framework of the curriculum of the educational program, with a limited time resource. All actions in the framework of educational activities began to take many times more time that was spent on connecting to the network, sending correspondence, checking, updating and sending reports and tasks. The volume and scale of correspondence has increased significantly.

The authors of the article solve these problems in the following way:

Teaching engineering discipline - processes and apparatuses of chemical technology can be constructed as follows. Integration of laboratory work and the introduction of test tests (replacing field experiments with video materials and uniting groups of students not by belonging to the educational program, but by studying the proposed topic if necessary) (Fig. 1).

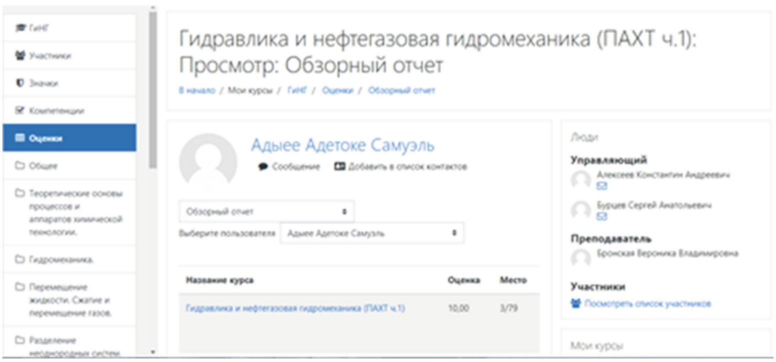


Fig. 1. Moodle test reporting example

Creation of personal folders of groups on virtual disks within the framework of the course project (Google, Yandex) in order to save time searching for files of the corresponding student, since there are a certain% of students who cannot upload their work to educational platforms due to limited technical capabilities (Fig. 2).

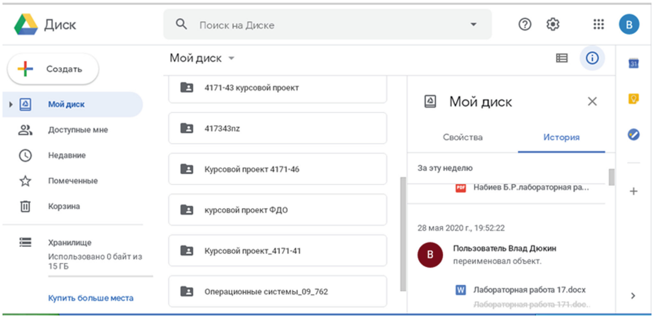


Fig. 2. Example Google Drive

Conducting lectures and practical classes, receiving term papers in the form of webinars on the platform Moodle, Zoom, Google, MsTeams (Fig. 3).

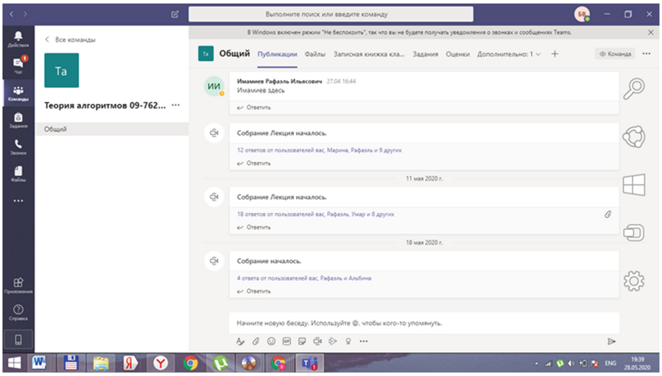
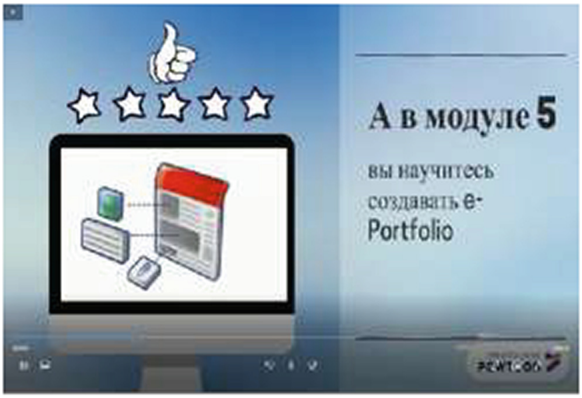


Fig. 3. An example of creating a team in MS Teams

As for the teachers of the humanities, then everything is simpler. In the discipline "Vocational Training Methodology", lectures using presentations are held at ZOOM, with a predominance of questions, discussion of various problems. This is used to energize students, as it is not always possible to track the presence of students (sometimes a photograph is presented), to determine the degree of ownership of the material. The text of the lecture two days before the lesson is sent to students using various communication sources. In this mode, practical classes are held. To increase motivation, we create colorful positive videos. As a control of knowledge, tasks for the logical interpretation of information and value judgments, tasks for the practical application of the studied information are used. These tasks in the form of an essay are sent to the teacher by mail.



The willingness of teachers to distance learning is largely determined by the skills of interactive interaction.

The faculty study was organized as a voluntary anonymous online survey. In total, the study involved 45 teachers aged 33–80 years, 34 women and 11 men. 60% of teachers rated the hasty organization of the transition to distance learning satisfactory, another 20% - poorly, and only 20% - good. The results obtained are not related either to gender, nor to age, nor to work experience.

Most university teachers have a diverse experience in interactive interaction, which primarily involves the use of applications for mobile devices (smartphones, tablets) to communicate on the Internet and exchange files that provide digital voice and video communication over the Internet between computers - Skype, WhatsApp, Viber, Telegram (86.6 and 55.5%). And almost 80% of teachers actively use the technology for receiving and transmitting short test messages - SMS (Short Message Service) using a cell phone. The results of this survey are shown in Fig. 4.

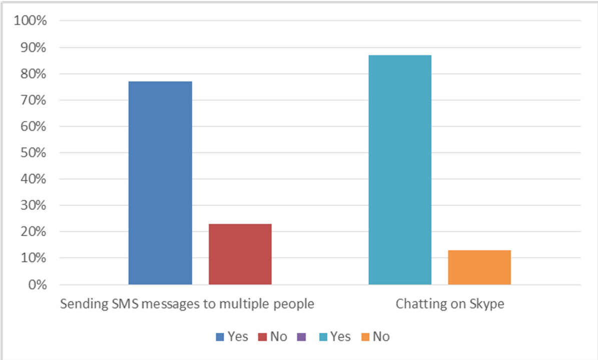


Fig. 4. Interaction skills %

The first is communication with friends on social networks or messengers.

As a source for searching for specialized information, including in the field of professional interests, the majority of students use search engines on a computer, on YouTube, on mobile phones - 77, 77, 72%, respectively (Fig. 5).

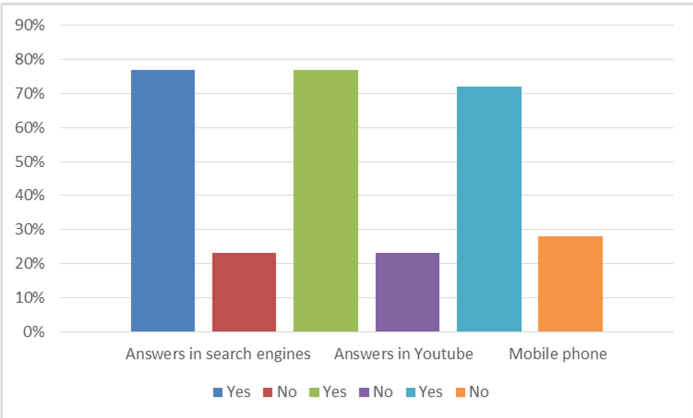


Fig. 5. Sources of information use, %

The questionnaire included a self-assessment task, according to the results of which teachers were able to assess their level of readiness for using remote technologies using the Likert scale. The results of self-assessment served as the basis for the classification and distribution of students in three groups (clusters). To build clusters, we used the clustering method, which is called the k-means method (k-means). We have identified three clusters that reflect the teachers' readiness levels for using remote technologies (Table 1).

We present the drawing in the language of instruction.

Table 1. Teacher readiness levels for using distance learning

Clusters	Number of teachers (%)
High readiness for online teaching and extensive experience in interactive interaction	53.3
Average readiness for online teaching	28.5
Weak willingness, little experience in interacting	18.2

The first cluster is characterized by teachers having extensive experience in using interactive interaction technologies. Almost all respondents (87.5%) included in this cluster are registered on social networks, exchange files by e-mail, communicate via Skype (online messenger), send text messages or make phone calls. The vast majority (95%) have a tablet. To listen to the lecture, search for the necessary and new information, 80% of the teachers in this cluster use search engines, YouTube, 50% read blogs.

Only 50% of teachers who fell into the second cluster are registered in social networks; they use online instant messengers to exchange information with their colleagues. About 66% of teachers send SMS messages, actively use search engines on the Internet, YouTube to view lectures, use all the capabilities of a mobile phone. More than 66% of respondents use special software applications and sites to search for reviews on the Internet to pay bills or reserve seats. Almost 41% of teachers have a tablet.

Teachers included in the third cluster are characterized by a weak applied application of modern technologies and means of communication. Of all the available means, the ability to send text messages using a mobile phone is most often involved. They don't have an iPad or another tablet, they don't use the Internet for personal purposes, such as buying tickets, paying bills. For interactive interaction via the Internet, 67% of the number of listeners of this cluster use the Skype program installed on the computer. 44% of teachers use search engines; 33% of teachers in this cluster share information with friends, colleagues on social networks.

We believe that one of the motivations of teachers to use distance technologies, to develop distance learning modules is the accumulated positive experience, acquired competencies in the process of working with computers, modern gadgets and their applications.

Having been working in remote format for 2 months, the significance of this form of education in the modernization of the educational system is recognized by 93% of respondents, 66.6% - "this will be one of the technologies, but not the leading one", 4.4% of teachers believe that technology will never replace a person and 55.5% of respondents believe that it is impossible to refuse personal communication between teachers and students.

Teachers (77%) more often complain of high workload and lack of time, 11% - of insufficient skills and knowledge in connection with the transition to distance learning. Least of all, teachers complain about the freezing of educational portals, lack of discipline of students.

Teachers also note that it is impossible to make high-quality distance courses with the speed now required. In order to transfer a live course to a distance course, it is necessary to use everything that a person uses during communication: facial expressions, tone, look, jokes, transferring spontaneous remarks with students. Today this is not, and this should be compensated by some pictures, infographics, animations, demonstration experiments, or something else. All this requires a lot of work, great effort and time. No one now has the resources to do this. In reality, students receive distance education in the format of a talking head. It is difficult to listen to a talking head for a long time [10]. Some of the teachers have enough artistry, while others do not.

The questionnaire conducted during the training gave the following results. Most students (73%) prefer traditional classroom activities with a teacher. Following the popularity and effectiveness after traditional classes, students noted the format of video lectures (68%), the main advantage for students was that the video can be viewed several times, paused, and rewound. At the same time, they noted a decrease in attention, which is maximum only when in contact with another person. When learning at a computer, the "glass effect" is turned on: the perception of information is reduced, as if the teacher was behind the glass in another room. In addition, during distance learning, students simultaneously include other gadgets. The level of anxiety of students who are taking a distance learning course for the first time is close to high. To the question "Rate your educational growth on a scale of 1 to 10, where 1 is completely unsatisfied, 10 is completely satisfied. Please explain the answer." 89% of students rate their educational growth above average (approximately equally at 5, 6, 7, 8, 9, 10 points). This is due to the temporary lack of part-time jobs, the lack of direct communication with peers and cultural leisure. Thus, the student was forced to devote more time to study.

5 Conclusions

Distance education allows for the individualization of instruction, namely, the student can study the material at a convenient time for him, have the time necessary for him to do this, and interact with the teacher. To ensure involvement in the learning process, it is necessary to determine the learning objectives (they should be clear to the student, discussed with him and accepted by him), content, implementation of feedback, use active working methods, forms of presenting content and monitor changes in the level of knowledge of students. The content of the material should provide a connection with reality (complexity of the material at different levels, options for presenting solutions), be based on the existing knowledge of students (provide additional material for those interested). Feedback should be prompt and formative, ensure participation in the discussion, answer questions, be able to conduct mutual evaluation and self-assessment. The teachers also noted the need to form a system of differentiated psychological, methodological and technical support.

According to teachers, distance learning has its weaknesses. Among them:

- lack of personal interaction;
- the problem of student motivation;
- lack of self-organization of students;
- complexity of quality control of assimilation of material;
- weak feedback;
- difficulty in evaluating results;
- heavy workload of the teacher in the preparation of distance learning courses and monitoring of assignments;
- the difficulty of accounting for the individual characteristics of students

Among the problems when switching completely to a distance learning system, teachers see the following:

- the computer does not replace the live communication of the student and teacher;
- teacher are not ready for the new;
- poor self-organization of students;
- the complexity of preparing good courses;
- knowledge control problem;
- deterioration in the quality of training.

The teacher during the training should be oriented to a specific audience, available technical resources. Next, you need to build a course strategy, conduct a technology search for the goals and objectives of the course. For the safety of the contingent during distance learning, it is necessary to have high-quality technical resources, quality of content, and exclude unwillingness to self-organization and educational inertia. To build content, you need new instructions and rules for its implementation. These include new approaches to the design and implementation of training sessions, containing new forms and technologies. The function of the teacher is also changing - from the translator of knowledge to the guide along the educational path and the facilitator. There is a need to more often use problem-based training problem-recommendation-tool for implementation-recommendations. In distance learning, as shown by the primary experience of teachers, such full-time pedagogical technologies can be successfully used as: project-based learning technology, critical thinking development technology, research teaching technology, individualized learning technology. However, their specific adaptation to the remote mode is required. It is necessary to ensure unity of requirements for conducting online classes and approaches of teachers to the organization of independent work. Teachers do not have a sufficient level of competence in the use of services to create online tests.

The student must be placed in a tight time frame, indicating urgency and limitations.

The reasons for the student's unpreparedness for distance learning are the inability to organize their independent work, to optimize workload for all types of activities, to study without external systematic control and stimulation. In general, students are ready for distance learning. Although not everyone had sufficient technical support and equipment to organize the workplace. Cognitive motives have intensified, reflecting the desire of students to self-education, focus on self- improvement of methods for obtaining knowledge. This is manifested in appeals to the teacher for additional information, clarifications. Students were interested in the resources that the teacher used to prepare the material and asked for links to the programs and services used. It should be noted that well-performing students during distance learning became even more active, while less successful students chose a wait-and-see attitude. Therefore, it is necessary to intensify their activities.

The hypothesis is confirmed that the main factor that impedes the work of teachers with distance educational technologies is anxiety, fear amid the novelty and lack of instrumental skills of the user with Internet technologies. Their readiness increases as organizational, methodological, and psychological difficulties are overcome through the unification of teachers to jointly solve problems and share their experiences. The problem of organizing the practical component of general engineering and special disciplines, which create a lot of problems for students in the absence of virtual laboratories, comes to the fore.

The study showed that most teachers are quite aware of the possibilities and forms of implementing distance learning and are aware of the advantages and prospects of its development. It should be noted that in the future, the integration of traditional and distance learning will be very useful for teachers and students and will achieve the results that the digital economy expects of us.

It is necessary to search for effective technologies of pedagogical interaction with students, a continuous increase in information and communication literacy, the formation of competencies and readiness for the implementation of new models of the educational process, the development of significant professional qualities should be priority areas for improving the activities of a higher education teacher in a digital educational environment.

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Professor's Image as Viewed by Engineering University Students

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Abstract. The higher education image contributes to the attitude towards the country in the globalized world. This image is formed due to different factors, among them is a university professor's image which is shaped by a variety of expectations from different social groups referring to the rights, obligations and standards such a professor is to follow. Although there is a lot of research done as for the professor's image and expectations of different stakeholders, there is a limited number of works analyzing the students' expectations. To bridge this gap, the paper aims at investigating the students' views in regard of a professor's image, comparing them with those of the other stakeholders and providing recommendations to follow. The paper uses both theoretical research methods based on the analysis of recent publications and discussions in the academic community and empirical methods in the form of a survey among students and its content analysis. The results show a mismatch between expectations of employers, community, professors and students as for the role of a professor in society in regard of their behavioral characteristics, research performance and leadership in teaching. The authors recommend that the professors prioritize the expectations from the students and teaching is the primary mission of the university. Further research could imply surveys among the employing university administrators and different societal groups.

Keywords: Engineering university · A professor's image · Stakeholders' expectations · Soft and hard skills

1 Introduction

Higher education is fundamental for society development, and universities contribute to supporting the progress of the country in its economic and cultural contexts. At the same time, the higher education image also shapes the attitudes toward the country in the globalized world. Therefore, it is important to examine the factors that contribute to the university image, thus bringing benefit to society by influencing these factors.

Different researchers have addressed the issues of higher education globalization and internationalization, highlighting their pros and cons, and analyzing their impact on the university image [1–4]. They state that multiple international rankings contribute greatly to the university image, and many of the indicators measured imply direct participation of the faculty members, including the number of publications in peer-

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reviewed journals, citations, and even the academic reputation index. Thus, these academic rankings show that a university professor's image is of a primary concern for the higher education system.

This image creates the public opinion and prestige rating of the university thus influencing its capacity to attract the best prospective students from different parts of the world [5]. A professor's image is shaped by a variety of expectations from different social groups referring to the rights, obligations and standards such a professor is to follow.

The universities lay emphasis on the mission of discovery, learning and engagement while the community expects every professor to direct their life properly and to encourage others to behave in the same manner. The emphasis on research brought to the forefront at engineering universities can, however, separate a professor from students thus undermining the main university mission, teaching and learning. Therefore, there is a need for a professor to know the students' views on her or his image so as to critically examine the practices involved and to adjust the strategies used to hold the students' attention.

The purpose of the present study is to determine the preferences of engineering university students for the image of a professor. Under current transformative conditions of higher education, this image is reshaped by managerialism, 'publish or perish' performance expectations, and digitalization preferences. Professors often feel a mismatch between their teaching priorities and those of their employing universities focusing on publications, applied industrial research and cooperation with businesses in case of engineering degree programs. In this highly competitive engineering university environment, the opinion of students is often ignored thus creating a gap between them and professors. Therefore, the paper aims at investigating the students' views in regard of a professor's image, comparing them with those of professors and university administrators, drawing conclusions on an ideal professors' image, and providing recommendations to follow for pursuing teaching excellence.

The hypothesis of the study is that engineering students have expectations regarding both professional (hard skills related to industrial experience and research) and personal (soft skills related to social values, sense of humor, and logical reasoning) characteristics of a professors' image. These expectations strongly influence their attitudes towards a professor, and moreover, their progress in the academic course taught and learnt. Alternatively, a professor can influence students' academic performance if he knows, recognizes and meets their expectations of her or his image, follows the practices preferred by the students and adjusts the teaching techniques properly. Thus, it is important to reveal students' views on a professor's image and use the revealed information for improving academic performance in engineering degree programs.

2 Methods

In order to get a better insight into the issue of a professors' image, the authors analyzed the views on the professor's identity, culture and role, as reflected in research literature including recent publications in research journals, conference proceedings, and in discussions in academic community and general society occurring in a face-to-face format or on different web-platforms.

Based on these publications and discussions, the authors drew their conclusions on the attitudes towards a professor's image from the perspective of the employing universities, civil society and academic community. The expectations of these various groups were summarized and categorized for a further comparison with students' views.

The student population selected for the survey consisted of 120 MSc students in engineering degree programs. The reason behind this choice was that, firstly, these students already have an experience of dealing with different professors throughout their Bachelor's and Master's degree paths, and, secondly, at this stage of education, many students consider an opportunity of continuing their career at a university. Therefore, MSc students are capable of giving their opinions of a professor's image based on good reasoning, but not only emotions.

The students participated in the survey by writing opinion essays to present their point of view on a professor's image supported by reasoning and examples. The essay was part of the academic course in Psychology and Pedagogy of Higher Education. The essays were evaluated individually, and then compared using content analysis method so as to reveal connections and relationship. As a result, several patterns characterizing a professor's image were distinguished and organized in categories. These categories were prioritized in accordance with the frequency of answers in the essays so as to get a general view of students on a professor's image.

A generalized students' view was compared to the above-mentioned expectations of various social groups. The comparison revealed a number of students' expectations which were never expressed by other social groups. Based on the students' expectations, the authors developed several practical recommendations for professors to follow in re-creating their image so as to serve as a role model for their students and to pursue academic excellence.

3 Results and Discussion

The research outcomes revealed a keen interest of different parties in shaping a university professor's image while identifying different priorities. There is a lot of research relating to this topic focusing on professor role preferences, their culture, competencies and leadership qualities from the view of different stakeholders. This paper considers the views of the society, the employing universities, and the professors themselves through analyzing recent publications in research journals, and the views of the students through a content analysis of their surveys.

The general public representing the society as a whole usually have certain beliefs in regard of the universities which tend to result from their personal positive of negative experiences and information from other sources. The university image is made up by the university's reputation, academic programs, employment of its graduates and professors who teach at the university [6]. A university professor's image, in its turn, is usually rated by general public in terms of prestige.

In general, the occupational prestige of the university professors is high all over the world, despite the reforms and political decisions in some of the East European countries where the salaries for this category of employees are significantly lower than in many other countries. The research of Stevens et al. [7] shows that professors are in the top 7 list of occupations in the US according to the following factors: level of social standing, honesty and ethical standards, importance to society and the nation, and challenging as an occupation. Thus, the professors are in the same list along with the lawyers, bankers, doctors, pharmacists, dentists and clergy.

At the same time, the occupational prestige of the university professor implies certain obligations to the society members who want to see them following a certain lifestyle, demonstrating ethical behavior patterns and creating a positive environment around them [8].

Moreover, the society expects the university professor to perform the service role for the local community contributing to its development. The earlier research of the 1960s [9] also gave another role to university professors in society, that is, character building role. Although recent publications very seldom focus on this role [10], discussions in society still emphasize these issues.

In regard of the employing university, it is evident that there have recently been many changes in the roles and responsibilities of the university professors. A century ago, the main responsibility of a professor was to teach and to conduct research. Currently, there is a strong emphasis on publications and academic services.

Recent research of Macfarlane [11] summarizes the institutional expectations of the professors in the post-1992 universities. First of all, the employing universities expect the professors to occupy both teaching and administrative positions either a faculty- or a university-wide, which include heads of departments, deans, directors for research or other activities).

Moreover, the universities and their authorities expect the professors to be leading in several spheres simultaneously, including research, teaching and income generation, to influence public debate and work of the university, to be a role model and to represent the department in the university. The professorial expertise is made use of in developing external links, serving on university committees and mentoring inexperienced researchers and senior managers.

Other publications show that there is a visible mismatch between the expectations of the employing universities and professors themselves, who are, first of all, committed to upholding standards of scholarship, and helping other colleagues to develop. This mismatch of expectations leads to stress and priority of one role over the other, thus having implications on either research or teaching [12].

Thus, the employing universities expect their professors to be, first of all, capable of leading cutting-edge research and generating income through cooperation with industrial enterprises and granting foundations. The society, in their turn, expects professors, above all, to inculcate high moral standards through personal experience and personal contacts with students. As for professors, they give a high value to upholding standards of scholarship and helping colleagues to develop.

Overloaded with these different, and, sometimes, opposite expectations, the professors have to clearly understand their personal goals and relate them to the society and university priorities. Moreover, expectations of the students as for the professor's image, should also be taken into account. No matter how important the university service and publications for the society are, the universities can exist only through relationships between professors and students [13]. Trust and indirect socialization underly these relationships, and without meeting the expectations of students, the universities lose their role in the society.

In order to define and analyze the expectations of the students, the authors conducted content analysis of surveys in the form of opinion essays written by MSc students majoring in engineering degree programs. The degree program curriculum included an academic course in Psychology and Pedagogy of Higher Education. The students who participated in this course were given a task to write an essay on their expectations of the university professor. The essay was called “An Ideal University Professor’s Image”. In total, a population of 120 students took part in the survey.

The research question of the survey was to categorize the characteristics of an ideal professor. A detailed analysis of the written texts gave a number of specific words and patterns to characterize a university professor. Some of the word and patterns were found repeated by different respondents while other patterns could imply the same meaning.

All 120 respondents in their answers pointed out the importance of loving the profession of teaching and loving students. Some students expressed it explicitly in phrases like “a professor should love his work of teaching and students taught”, “a professor should love the things that he teaches and the students who study”, “he adores students”, “a professor who loves, or, at least, is interested in his course”, “a person who chose this profession because he loves it”.

Implicit phrases which highlighted the same characteristics were “a professor is bright-eyed when he communicates with students”, “a professor always finds an approach to each of the students”, “a person who puts his heart and soul into teaching students”.

Thus, the students’ essays revealed the most important characteristic of a professor either in an explicit, or in an implicit form, as love towards the teaching profession and students.

Further analysis showed that, in general, students wrote about two types of skills, soft skills and hard skills. Soft skills were classified into the following categories: teaching skills, communicative skills, digital skills, and adherence to social values. Hard skills were categorized into expertise in the course taught, research in engineering and hands-on-experience.

All survey participants in one way or another mentioned both soft and hard skills in their essays with a stronger emphasis, however, on soft skills.

Table 1 gives the summary of the most popular words and patterns used in the essays to describe soft skills. In total, all the respondents (100%) prioritized teaching skills, 97 respondents (81%) considered communicative skills as important, 85 respondents (71%) gave value to digital skills, and 75 students (63%) mentioned adherence to social values.

Surprisingly, “sense of humor” appeared to be the most popular word pattern in the essays followed by “a talent to teach”, “the use of computer during classes”, “a good speaker”, “a friend to students” and “a good person”. In regard of communicative skills, 7 respondents mentioned intercultural communication necessary to succeed in making contacts with foreign students which is relevant for cross-cultural engineering projects [14].

These content analysis results prove the importance of ideas discussed recently at international conferences regarding the ideas of using active learning methods [15], significance of improving the teaching skills at an engineering university [16], and developing communication skills [17]. Although the essays were written long before the COVID-19 outbreak and distance learning practiced and all the universities, the respondents gave a high value to digital skills of professors in the context of digital economy [18].

Adherence to social values was implied in word patterns "a good person", "good manners", "helping others" and so on. Some respondents were very specific insisting on the importance for the professors to keep fit and not to smoke, which reflects the role model of the professors imposed by the society.

Table 1. Soft skills of a professor as viewed by students.

Categories of soft skills	Students' expectations
Teaching skills	Sense of humor (85), a talent to teach (72), a good speaker (68), inspiring students to learn (62), inspiring students to think (39), encouraging students to compete (28), readiness to learn from students (22)
Communicative skills	A friend to students (67), ability to compromise (54), benevolent to students (43), face-to-face communication (41), story-telling (38), easy to contact (35), emotional contact (31), encouraging teamwork (27), creativity in communication (25), intercultural communication (7)
Digital skills	The use of computer during classes (72), making and giving .ppt presentations (53), responding to e-mail messages (46), expertise in software (36), using digital communication tools (30), using social networks (25), using of visual aids (25)
Adherence to social values	Being a good person (64), good manners (52), well-dressed (43), keeping fit (35), timeliness (25), helping others (24), trust to students (21), self-discipline (18), optimism (15), open to changes (13), no smoking (8), responsibility for the country (6)

Table 2 illustrates the words and patterns used by the respondents to describe their expectations of the professors in terms of their hard skills. Overall, 100% of respondents mentioned the expertise of the university professors in the academic course that they teach. At the same time, only 86 respondents (72%) prioritized the importance of doing research in engineering, and even less than that, roughly half the number, 63 respondents (53%) emphasized hands-on experience in profession.

The most frequently used word patterns were "knowing the course content", "ability to answer questions beyond the course taught", "loving the course taught", "leadership in course content" and "a broad professional outlook".

All the respondents placed a premium on the expertise of the professors in the course taught meaning that they have a deep knowledge in the subject matter of the course and can present it to the students in the most appropriate form emphasizing the most essential information.

These ideas were expressed in both explicit and implicit phrases, e.g. "this person should know the course and all its details taught, and should answer the questions which the students might ask", "to be a professional in the sphere of the academic course so as to answer all the questions from other professors and students", "to be committed to the academic course", "a craftsman in the academic course".

Research in engineering was less highlighted in the texts of the respondents, nevertheless, the students outlined the importance of cutting-edge research and their respect towards those professors who have high ranking publications [19] and who can supervise students in their research [20].

Table 2. Hard skills of a professor as viewed by students.

Categories of hard skills	Students' expectations
Expertise in the course taught	Knowing the course content (92), loving the course taught (63), leadership in course content (54), continuous development in the course taught (48), categorizing the essential information (36), deep knowledge of the course (27)
Research in engineering	Ability to answer questions beyond the course taught (63), a broad professional outlook (52), leading specific research in his field (35), current trends in specific field of science (23), qualified in his field (17), achievements in research (11), interdisciplinary research (8)
Hands-on experience in profession	Giving real life examples (46), knowing the practical application of the course (34), experienced in practice (32), demonstrating knowledge in practice (32), knowing what is happening in industry (16)

Although hands-on experience in profession received the least attention in the students' essays, some phrases were very appropriate to the topic, e.g. "have experience of not only teaching the academic course, but also working in this sphere", "follow the progress in this sphere", "no less than 3 years of professional experience in industry". The students demonstrated that they value those who can share their practical experience and teach them to use modern devices and equipment [21].

Thus, in the view of the students, a combination of soft skills and hard skills make an ideal university professor. Such a professor can develop and teach innovative engineering degree programs [22], while these skills can also be applied in any other degree programs and their modules [23, 24].

In general, all the soft and hard skills that the students expect their professors to demonstrate imply metacognitive skills [25]. These skills refer to organizing, guiding and controlling your own processes of thinking, learning, and acting. Thus, the image of a university professor can be completed by adding metacognitive skills to soft skill sand hard skills.

When compared to the expectations from other stakeholders of the educational process, the professor's image as viewed by the engineering university students does not include any publications or services to the academic community or society as a whole. However, these responsibilities make an integral part of any professor's image which cannot be ignored. Therefore, the professors are challenged to meet all the expectations simultaneously which is very hard to implement. Nevertheless, the professors are urged to give priority to students' expectations as teaching has always been the primary mission of all universities.

4 Conclusions

The study showed that there are many factors that shape a university professor's image. There is clearly a degree of mismatch between expectations of employers, community, professors and students as for the role of a professor in society in regard of their behavioral characteristics, research performance and leadership in teaching. While staying relevant to all stakeholders' expectations, professors should always set priority to the views of their students, as teaching and learning is the main university and professoriate mission. Above all, students value enthusiasm in profession and sincere interest in improving teaching practice. A list of recommendations for professors to follow also includes high quality communication skills, digital competencies, and adherence to social values. A professor inspires students acting as role model, a mentor, an advocate, a guardian and an ambassador of good will.

In response to these findings, all stakeholders might take into account the expectations of other groups. Universities might develop mentoring programs for newly appointed and experienced professors aimed at improving their soft and hard skills in accordance with the views on a professor's image from different groups involved.

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Extracurricular Activities as an Important Tool in Developing Soft Skills

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Abstract. The paper examines the potential of extracurricular activities as an important tool for developing soft skills and assesses its significance to engineering university students. Based on empirical research the research evaluates how extracurricular activities contribute to the development of soft skills. In the 21st century higher engineering education faces big challenges to prepare competent graduates in order that they are competitive in the global market, rapid technological advancements affect all aspects of people's life, globalization results in competition growing, increase of migration, climate change and culture of sustainability. Educational policies are made to improve the quality of education, where the main priority is to develop hard skills rather than soft skills. The main purpose of education system is to foster soft skills throughout all layers of education including not only academic activities but also non-academic attributes should be taken into consideration. And in this term extracurricular activities play an important role in socialization and offer a powerful resource for personal development and acquisition of various soft skills that may not always be developed during classroom activities.

Keywords: Extracurricular activities · Soft skills · Engineering university

1 Introduction

1.1 Research Background

Technological, economic, social, cultural and political changes define new profiles in view of what the enterprises need from their professionals and in order to solve the enterprises' problems, technology is not enough; rather more humanism is necessary [4]. Developing soft skills and competencies, such as the ability to solve problems, teamwork, handle information, communication are considered as necessary measures for achieving employability. Researchers also confirm the growing relevance of soft skills in Russian labor market, when academic credentials lose their position to personal characteristics [2, 14]. But what are the most effective ways of integrating these skills in engineering university since they are not part of formal curricula? There a lot of studies suggesting different means of developing students' soft skills, but most of them consider this problem as a part of academic curriculum [8, 12, 13]. Besides recent changes in Russian educational policies made to improve the quality of education prioritize hard skills development rather than soft skills. All this defines the urgency of

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our research which we see in necessity to foster soft skills through extracurricular activities in engineering university.

In our research we assume that extracurricular activities have enormous potential for soft skills acquisition but they also promote positive educational outcomes. The purpose of our study is to examine the potential of extracurricular activities as it relates to the development of soft skills to assess its significance to engineering university students. Based on empirical research to evaluate how extracurricular activities contribute to the development of soft skills.

Extracurricular activities are quite essential to any student's learning experience as they contribute to their academic achievement and can be a powerful recourse for soft skills development. As M. Donnelly et al. note [5], apart from their inherent value, trough organized extra-curricular activities young people can also develop positive tangible outcomes from interacting and working with others, which could benefit them in later life.

The definition of extracurricular activities is not formally adopted by scholarly literature. Often extracurricular activities are treated as self-explanatory, with little or no further explanation. Review of the literature suggests a considerable variation in the term extracurricular activities, and how they are defined and measured. Extracurricular activities are defined as academic or non-academic activities that are conducted by student associations, student divisions and/or individual students under the sponsorship of the school, but occur outside of normal classroom time and are not part of the curriculum [11]. Besides, they don't provide any academic credit and student's participation is optional. As some researches note, extracurricular activities exist at all levels of education, from primary to tertiary education and are valuable experiences for all students [7, 16].

1.2 Material and Methods

The study takes a brief look at understanding and definitions of soft skills and extracurricular activities. Content analysis of scientific literature and desk-based research make it possible to gather existing available evidence on the significance of extracurricular activities as well as the importance of soft skills in the labor market and for social mobility. The data collection technique included self-assessment questionnaire and observation to find out the perception of soft skills by students. The study involved 70 engineering major Bachelor students from Kazan National Research Technological University. The developed questionnaire contained questions to measure students' communication and negotiation skills, leadership qualities, their ability to solve problems and manage conflicts, think critically and independently, work in teams and their creativity. Participation in questionnaire was voluntary and anonymous, before conducting the survey we the research objectives and soft skills concept. The research methodology is linked with engineering education modernization and lay on student-centered approach which enables students to be actively involved in various activities.

2 Results and Discussion

2.1 Skills Gained from Extracurricular Activities

Conflict Management and Collaborative Problem Solving. Extracurricular activities improve the students' capability to solve problem and resolve conflicts. Skills in conflict management allow them to cope with various kinds of tense situations. In addition, they are able to identify potential conflicts in their environment and resolve differences. The ability to effectively manage conflicts, debates and open discussions helps to possible to avoid misunderstandings and maintain a harmonious relationship with people. Collaborative problem-solving and conflict management involves developing other key skills, notably creativity, critical thinking, communication, resilience, initiative, cultural awareness and social intelligence.

Communication and Negotiation Skills. Students involved in extracurricular activities gain better communication and negotiation skills through developing relationships with their peers, maintaining a conversation and acting effectively in critical situations when communicating with others. Activities aimed at communication and negotiation processes foster long-term cooperation and teamwork. Students learn how to express their position through verbal and non-verbal techniques, taking into account the specifics and interests of the second party.

Leadership. Extracurricular activities enhance student's leadership abilities. They are able to develop students' confidence to be a leader, inspire and guide groups of people, maintain team spirit and articulate personal qualities. Activities done by teams and the leader promote creative potential and active interaction of team members. Students in leadership positions learn to listen to others and give their opinions. Having learned leadership skills in engineering educations researchers came to conclusion that when students communicate their ideas they inspire others to follow them commitment and dedication, transmit a sense of confidence to others that facilitates further success [6].

Critical and Independent Thinking. Certain extracurricular activities encourage students to find information and understand different approaches, ask questions and think 'outside the box', produce unconventional ideas and offer good solutions taking into account all recourses. David T. Conley finds that "habits of mind" such as analysis, interpretation, precision and accuracy, problem solving, and reasoning are more important than content knowledge in determining success in college [3].

Creativity. Extracurricular involvement foster creativity better than any other academic activity, students demonstrate non-standard and innovative approaches in problem solution. According to Robert Sternberg, successful individuals are those who have creative skills, to produce a vision for how they intend to make the world a better place for everyone; analytical intellectual skills, to assess their vision and those of others; practical intellectual skills, to carry out their vision and persuade people of its value; and wisdom, to ensure that their vision is not a selfish one [15].

Teamwork. Extracurricular activities are ideal for teamwork. Students feel themselves as a part of the group, try to operate and communicate efficiently within a group, contribute new and innovative ideas, see and understand diverse opinions. While working in different student committees, associations they develop team spirit sharing responsibilities and tasks. As researchers say, people with the ability to work in a team are endowed with such qualities as respect, willingness to cooperate, organizational abilities, and the ability to attract all members of the team to active participation, trust and determination [17].

According to our observations, the degree of formation of soft skills among students is quite low. We often notice that students have good level of technical and academic abilities but their soft skills are letting them down as most of the times they do not provide proper communication and teamwork. Moreover, they don't listen and conduct a conversation that is comfortable for everyone; they are not familiar with the methods of persuasion. The results of students' questionnaire demonstrate the same trend (Fig. 1). In our study we used the Self-Assessment of Key Competencies test developed by Competency Laboratory of the Southern Federal University Career Center [9].

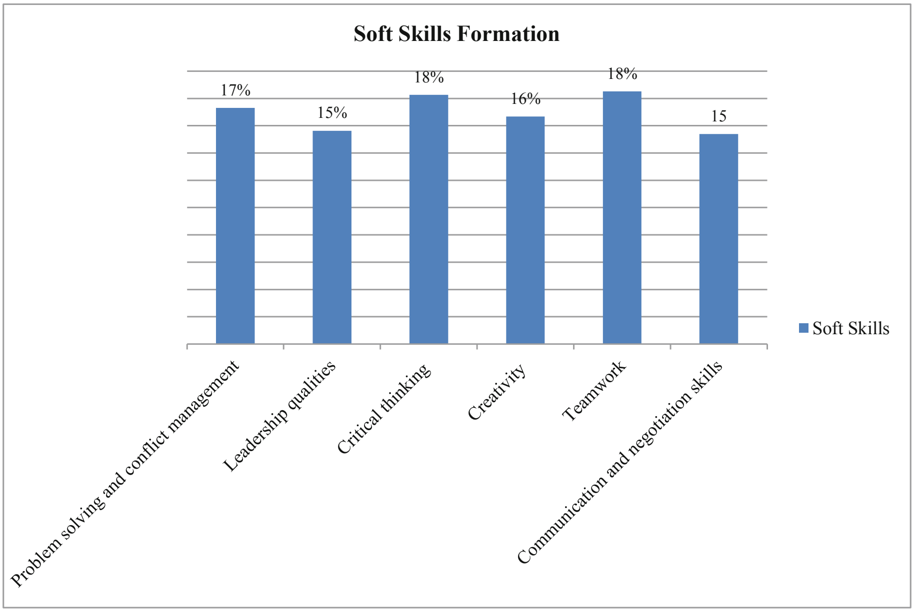

Fig. 1. Questionnaire results on soft skills development among students

As the diagram shows, 18% of students named teamwork as their strong point, many students in Russian universities study in the same student group for 4 years and therefore develop some teamwork skills. Also, critical thinking skills are developed in 18% of engineering students, and 17% of respondents believe that they have problem solving and conflict management skills. Leadership and communication and negotiation skills are least developed. We are trying to organize those extracurricular activities that are aimed at developing the above skills that are necessary for a future engineer in his professional activity.

2.2 Types of Extracurricular Activities

The primary goals of extracurricular activities focus on the individual student level, the institutional level, and the broader community level. According to Astin, almost any type of student involvement in college positively affects student learning and development [1]. Well and properly organized extracurricular activities will make a positive impact on students' academic, social, personal, emotional development. In our paper we discuss the most successful and common on our university campus out-of-the-classroom activities. Offered extracurricular activities depend on the diverse interests of university students and range from social organizations to regional athletic programs. We observe how this involvement in extracurricular activities helps students-participants of our questionnaire to learn to communicate, manage conflicts, lead others and negotiate.

"Freshman's Day" consists of several stages and end with a gala concert. The main condition for participation is being a first-year student. Festival preparation takes approximately six weeks when students come up with vocal, dance, poetry, theatre performances. The preparation process creates an excellent opportunity for students to meet each other and develop such qualities as artistry, good taste, sociability, patience and empathy within the team. Freshmen demonstrate different musical performances, various comical situations that occur in student environment and their dramatic abilities. "Freshman's Day" unites people with different cultural background, international students also participate there so the festival focuses on increasing awareness and understanding of various cultures, it is an important step toward positive racial and ethnic development. Students demonstrate their ability to cope with different problems during the preparation, develop teamwork and leadership skills, boost their confidence by learning how to perform onstage.

The *Military-Patriotic Song contest* is an annual musical event dedicated to the Victory Day (May 9th) is organized by a huge number of talented young performers from different educational institutions for military veterans and university staff. Participants demonstrate their talents by singing war-time songs, reading verses about the war. This event contributes to the formation of national identity, enhances the feeling of patriotism among the younger generation and strengthens inter-ethnic relations.

For *"Polyglot" competition* students are united in teams of 4–5 people. The competition consists of various quizzes, musical performances and short presentations. Engineering major students minoring in English demonstrate their knowledge about cultures, customs and traditions of Great Britain, the USA and other English-speaking countries. Such activity promotes multicultural awareness on campus as students see the cultural differences between the country of their origin and English-speaking countries. Collaborating with each other within a team students demonstrate their greatest strengths, build an effective dialogue with each other and learn to listen to their peers. The competition creates a favorable emotional environment and helps strengthen relationships providing an opportunity for students to show their organizational skills. "Polyglot" competition develops the ability of student to communicate effectively and appropriately with representatives of other cultures and foster appreciation of cultural diversity and openness for different points of view.

University Sports Activities. The University offers different types of team sports such as volleyball, basketball, or soccer. Being an athlete requires a great commitment of time and energy for practicing and competing. Besides every year university sports complex hosts a sports festival which includes track-and-field, tug-of-war and cheerleading competition. Such athletic events are able to create a friendly atmosphere and foster endurance and team spirit as good results can be achieved by team efforts.

Volunteering for different organizations, supporting Blood Donor day, participating in community service projects, planting trees, ecological marathons – all these initiatives with University students involvement make them feel the most accomplished and make the greatest impact on them. Volunteer activities help to improve the local and national community which is an important goal of extracurricular activities. These types of extracurricular activities create avenues where students get socialized and enhance self-identification, self-assessment and social awareness skill, become responsible towards society (Table 1).

Table 1. Types of extracurricular activities that help to integrate measured soft skills

Types of extracurricular activities	Social skills
Student's Spring Festival	Negotiation and Communication Skills
Freshman's Day	Teamwork
Volunteering	Conflict Management and Problem-Solving
Student's Theater Club	Leadership Skills
Military-Patriotic Song Contest	Critical and Independent Thinking
Blood Donor Day	Creativity
Beauty Contest	Flexibility and Adaptability
My profession – my world	Time Management
Polyglot Contest	Self-Motivation
Intellect Show	Responsibility
Science Day	Empathy
Students' Career Day	
Earth Day	
Sports Day	
Students' Associations	
Students' Community-based Organizations	
Student Union	
Sports Club	
Students' Newspaper	
Video News Service	
Volunteer Squad	
Tutoring	

3 Conclusion

In our study we examined the role of extracurricular activities in soft skills development. Our thesis was that consistent participation of engineering university students in extracurricular activities promotes personal competences which can be the ground for further career success. Mahoney et al. [10] reported that persistent participation in extracurricular activities is associated with educational success, and promotes interpersonal competence not only in young adulthood but also in college attendance. The following features are distinctive for non-academic activities:

– the participation is not required by university curricula that means that students are interested in them and enjoy them;
– extracurricular activities are well structured meaning that there is a leader who organizes and a team helping him or her, regular meetings for discussions;
– these activities can be quite challenging and require a lot of effort from students.

Working outside of the classroom with each other allows for the development of crucial life-skills that cannot be replicated in the classroom. Students have opportunity to improve their leadership and teamwork skills while also increasing their self-confidence, better understand their talents, abilities and career goals. Students actively engaged in extracurricular activities develop high research ambitions as outside-the-classroom involvement has a positive impact on educational attainment and aspiration. University campus is quite complex and diverse, and it's very important to build and sustain a community where students feel comfortable. Extracurricular activities provide a place for students to come together, discuss pertinent ideas and issues, and accomplish common goals. The questionnaire and students' answer show that as engineering university educators we need to maintain students' participation in extracurricular activities, attract them to interact with their peers who have similar interests, provide social integration.

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From the Classroom to Home: Experiences on the Sudden Transformation of Face-to-Face Bioengineering Courses to a Flexible Digital Model Due to the 2020 Health Contingency

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Abstract. During these first months of 2020, the world is experiencing the most ruthless health crisis in modern history. This has led different areas of society to change their lifestyle or the way they are carried out. One of them is teaching, especially engineering education. This has required a sudden transformation of the methodology and the use of digital tools, as well as the training of teachers in an expeditious manner. The Tecnologico de Monterrey, one of the best private universities in Latin America, stopped its activities on March 20 to promote social distancing as a security measure against the COV19 (SARS-2-COV coronavirus) pandemic. This implied that at week 6 of the spring semester 2020, the courses would suddenly become a part of a newly implemented flexible digital model from home for both, the teacher and the student, preventing attendance to school facilities. In this manuscript, we analyze the response of 3 groups of specific subjects from the Bioengineering Department that were migrated. One of these subjects was precisely the Microbiology Laboratory for Engineers, which involved a major challenge. The teachers received adequate training for a week and students were then transferred to the new synchronous online model. Knowledge acquisition analysis and satisfaction surveys showed that the implementation of this digital model was adequate to achieve the academic objectives set from the beginning of the 2019–2020 academic year.

Keywords: COVID-19 · Challenge Based Learning · Educational innovation · On-line learning · Higher Education

1 Introduction

1.1 An Unexpected Event

In August 2019, at the planning meetings for the fall 2019 and spring 2020 semesters, we never imagined what would await us or that the face-to-face courses we offer would

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have to be moved to a remote version. In December 2019, cases of a group of sick people with an unknown type of pneumonia were reported for the first time in Wuhan City, capital of the People's Republic of China [1]. Most of the affected individuals were workers at the Wuhan South China Wholesale Seafood Market [2]. The contagion curve and the epidemic became very dangerous and the world watched with amazement the increase in deaths and in the number of cases (Fig. 1).

The 2019–2020 COVID-19 is a pandemic derived from a coronavirus disease, caused by the Severe Acute Respiratory Syndrome CoronaVirus-2 (SARS-CoV-2), identified as a highly contagious virus with high mortality. The cases quickly spread outside of China and countries like Italy experienced a rapid expansion of the virus in their population (Fig. **1**). The World Health Organization (WHO) recognized it as a global pandemic on March 11, 2020 [3, 4].

As of June 6, more than 6.8 million cases of the disease have been reported in more than 213 countries and territories in the world (the five countries with the highest number of infected people are United States, Brazil, Russia, United Kingdom and Spain). More than 399,000 deaths (the five countries with the highest number are United States, United Kingdom, Italy, Brazil and France) and more than 3 million cases of people recovered (the five countries with the highest number of people recovered are the United States, Brazil, Russia, Germany and Italy).

The virus is usually transmitted from person to person through tiny droplets of saliva, known as Flügge microdroplets, which are emitted when speaking, sneezing, coughing, or exhaling. The virus spreads mainly when people are in close contact, but it can also be spread by touching a contaminated surface and after touching contaminated hands to the face or mucous membranes. The governments of the affected countries in the first three months of the year established home confinement, restricting mobility and thus restricting access to schools [4].

In March, the pandemic was growing in Europe (Fig. 1) and the countries of America were preparing their strategies to be able to face the imminent arrival of the pandemic to the continent. In Mexico, the first case of COVID-19 was reported on February 28, 2020, and as of June 7, the Government had reported 113,619 accumulated cases of infected people. How to react in an educational institution to this imminent event? What strategy to follow to give continuity to the courses initially planned as face-to-face and transform them to be online in the middle of the semester? For all education at all levels, it was a disruptive moment. In this manuscript, the results of the conversion of three face-to-face Bioengineering courses to online courses are presented. Our data indicate that, although they did not lose concepts, and all the topics were reviewed, the competency assessment was a difficult item for the teachers. The future of the pandemic is still uncertain, so is the date of return to the classroom, so we must be prepared for even greater challenges.

2 Scholar Settings

2.1 Courses Analyzed, Changing the Scholar Framework

On March 20, 2020, the authorities of the Tecnologico de Monterrey decided to close the 26 campus of the university nationwide, in an unprecedented action and becoming the first educational institution in Mexico to make a decision to protect the collaborators, students and teachers of the educational establishments. This decision was based on the need to stop the rapid spread of the SARS-CoV-2 virus causing COVID-19 disease [4]. At the time of submitting this document, there is still no date for reopening.

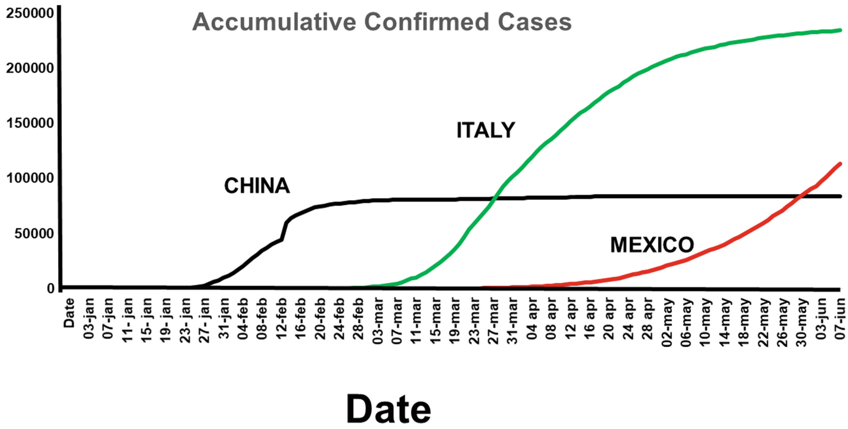

Fig. 1. Accumulative confirmed cases of COVID-19 in three different countries. The date of the data is shown in the X-axis and the accumulative number of cases is depicted in the Y-axis [5]

Thus, 92 thousand students from Tecnologico de Monterrey, more than 19 million Mexican students of all levels and, in general, the more than 1,500 million students worldwide stopped taking classes at their schools. It is known that the closure of schools may be (together with the prohibition of large public gatherings) the most effective measure to slow the progression of the disease [6]. This measure is particularly justified by the rapid spread of the virus in children and adolescents, which could be even greater than in adults [7]. Teachers who took this pandemic by surprise are still unaware of the implications this measure will have on student learning and what will happen when schools reopen. At this point, we can report on the interrupted courses and analyze their performance measures.

On March 20, by interrupting classroom activities, the Tecnologico de Monterrey took a week (from March 23 to 27) for teacher training. Table 1 establishes the different training topics to which the teachers were subjected. It does not escape to our attention that the current situation reveals several problems that the Mexican educational system in general has to face: The crisis has forced the migration of educational systems to online mode immediately and abruptly, which has given rise to a "remote emergency teaching" [8]. The current crisis leaves no room for planning and designing the learning experiences that characterize authentic online education. Very important, it is necessary to reflect on how the end of the course would be evaluated.

Table 1. Training topics for teachers and difficulties

Topic	Purpose of the training element	Teachers remarks
ZOOM	ICT	Digital migrants, Time too short to get all the information
CANVAS	Course teaching	Digital migrants, Too complex for a course transformation
TEAMS	ICT	Digital migrants, more friendly than Zoom, but still quite complex
SOCRATIVE	Evaluation	Easy to use for on-line evaluations

The initial hypothesis implied that after the closure of schools, there would be a negative impact on the learning of all students; and on the other hand, this impact will be much greater for students from environments with difficulties to access information and communication technologies (ICT). The sudden migration of teaching activity from the face-to-face model to the online model shows the existence of three gaps [9]:

- Access gap (having or not having access to ICT devices).
- Use gap (Experience in its use).
- School gap (teaching skills, availability of resources and adaptation of online platforms to support teaching).

In the course schedule for the spring 2020 semester, it was determined that within the academic load, three courses would be implemented for Bioengineering students from the second and third semester, Biomimetics and Sustainability, Genetics and Microbiology Lab (Table 2). All courses would have the engineering vision required for the objectives of the Tecnologico de Monterrey, one of the best universities in the world (155 according to the QS ranking of 2021) and the best private university in Mexico.

Table 2. Courses analyzed in this research.

Course	Teaching Technique	Remaining sessions after the break
Biomimetics and Sustainability	Challenge based learning	14
Genetics	Project based learning	14
Microbiology Lab	Practical based learning	7

3 Results and Discussion

3.1 Biomimetics and Sustainability

This course is designed under the Challenge Based Learning technique in the new Tec21 model [10]. Students analyze the problem, seek an answer in a multidisciplinary environment and develop transversal competencies such as collaborative work, critical thinking and resistance to failure; on the other hand, disciplinary competencies are developed such as integrating the concept of sustainability, clean and renewable energy into different solutions to challenges.

Thirty-one students were taking the classroom course when it was decided to convert the course into a distance course due to the COVID-19 pandemic. The lecturer of the course was trained in ZOOM and SOCRATIVE (Table 1) to continue with the course. Figure 2 establishes the grades obtained by the students during their last (third) grading period and final exam; this is after 14 online sessions. The most complex part of this course is solving the previously established challenges [10–14] only with online resources; one in particular had an extensive discussion regarding the engineering principles of the biophilic model of a football stadium.

3.2 Genetics

This course is designed under the technique of Project Based Learning, where students develop investigations that solve a problem previously explained in class, the concepts are discussed and the evaluation rubrics of the projects to be developed are established. Transversal competencies such as collaborative work, critical thinking and information search are developed. On the other hand, disciplinary competencies are developed such as the integration of technical concepts such as PCR, Microarrays, and fundamental bases of genetic engineering. This particular course was of great interest on the part of the students due to the situation of the pandemic.

Twenty-five students were taking the course in the classroom when it was decided to convert the course to a distance course due to the COVID-19 pandemic. The course teacher received training in ZOOM and TEAMS (Table 1) to continue the course. Figure 2 establishes the grades obtained by the students during their last (third) grading period and final exam, the last two were carried out afterv14 online sessions (Table 2).

3.3 Microbiology Lab

Two groups of this course (21 students in total) carried out their 7 remaining practices in an online mode. This class was a very difficult challenge for the regular teachers of the course because it is not easy to develop laboratory skills in a virtual environment. It was possible to obtain licenses from different simulators of laboratory techniques; this did require a collegial effort by all the teachers at the national level to be able to carry out the practices.

The Microbiology Laboratory course is designed under the technique of Practi-calBased Learning, here students follow a path to carry out the practices and are evaluated afterwards to establish a performance rating. The tenured teachers were not only trained in ZOOM and TEAMS (Table 1) to continue the course, but also in various simulators of bacterial growth and in biotechnological process engineering. Figure 2 establishes the grades obtained by the students during their last (third) grading period and final exam; the last two were done online during 7 sessions (Table 2).

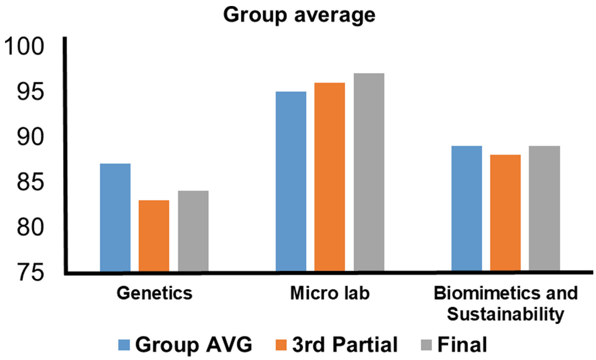

Fig. 2. Average achievement of the groups of the three courses studied. **Group AVG** describes the group's average grade during the face-to-face weeks before switching to online classes. **Third partial** and **final** grade are using ICTs.

3.4 Conclusions

Our data clearly indicates that the hypothesis of a drop in student achievement was not true in any of the three courses studied. The Genetics course, under the Project based learning technique, was the most affected course, compared to the Laboratory course that is designed in Practical based learning. It is notable that the Biomimetics course, offered under the Challenge based learning technique, apparently did not have an impact on the grades, which implies that the resolution of challenges perhaps has more to do with finding the solution rather than with the method used. This is consistent with previous reports [13, 14].

Our results indicate that at least students responded robustly to the sudden change in teaching, from an on-site class to an on-line class. More studies have to be done to establish whether teachers and students find improvements in distance learning teaching-learning techniques. Special attention is given to the laboratory course that opens an area of opportunity little explored, to have virtual laboratories with only simulators.

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Evaluation and Outcomes Assessment

Evaluating Construction Education Interventions

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Abstract. The evaluation of engineering education interventions is important to gauge their impact and whether they achieve their intended objectives. Building Information Modelling (BIM) educational interventions are increasingly common at universities globally and their implementation is often accompanied by ad hoc evaluation practices and sometimes little evaluation at all. The aim of this study was to investigate existing evaluation practices among engineering educators, in particular technology mediated interventions and determine an appropriate evaluation methodology for BIM for Construction Education (BfCE) pilot initiatives. Academic articles and educational (non-research) guidance literature were reviewed to identify existing evaluation models. In addition, reported cases of BfCE were reviewed to identify specific approaches that have been applied to evaluate such initiatives. The study found that the use of evaluation models in engineering education is low. In addition, little evidence of the use of evaluation models in relation to BIM education interventions was found indicating a need to increase awareness among engineering educators on the importance of evaluation in promoting engineering education. An evaluation framework was derived to support engineering educators to more effectively evaluate their BfCE interventions.

Keywords: Educational evaluation · Building Information Modelling (BIM) · BIM education · Evaluation · Assessment · Construction education

1 Introduction

Studies have shown that introducing technology into didactics enhances learning and increases the motivation of students to learn (Wu and Kaushik 2015; Barham et al. 2011; Lopez-Zaldivar et al. 2017). “Building Information Modelling (BIM) is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of” construction projects (“Building information modeling - Wikipedia,” n.d.). The desire to leverage the opportunities presented by BIM for engineering and construction education has led to efforts to design and execute pilot “BIM for construction education” (BfCE) pedagogical interventions (Olowa et al. 2019). Construction education has been criticized for the mismatch between graduate competencies and their professional roles in industry (Forsythe et al. 2013). By enabling the use of real

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construction project data and simulating more realistic, multidisciplinary workflows in the educational environment, BfCE offers opportunities to enhance construction education didactics to better align graduate's competences with emerging and future needs, particularly those arising from the digitalization of the construction industry. This has been generally recognized and initiatives to develop curricula to incorporate BIM have become widespread.

However, measuring and determining the effectiveness of such interventions have always been a challenge. The literature contains a plethora of models and approaches for educational evaluation and assessment proposed by various authors for both programme and course evaluations together with their attendant criticisms (for example, see Stavropoulou and Stroubouki 2014; Gordon 2018; Chinta et al. 2016; Anh 2018). Although Anh (2018) observes a spike in the attention given to evaluation among education practitioners in recent times, McCuen and Chang (1995) opine that most engineering evaluations are done retrospectively by the instructor in charge of the course with concentration on the implementation, and evaluation specifically based on the students' grade assessment. Little attention is given to the likely impact that the teaching style, institutional environment, teacher-student relationship, student-student relationship, classroom process and the general societal culture and values may have on the performance of the course. Additionally, most existing reports of BfCE trials lack clear descriptions of the evaluation methods adopted and the few reported evaluation activities suggest a focus on students' academic performances without adequate consideration of other, incidental and contextual factors that may have influenced the outcome of the interventions. Students' performances may be more objectively evaluated when there is a control group for comparison, but, in the absence of one, there is still a need for reliable approaches to evaluation. Behaviorist learning theory, which predicates evaluation on carefully established objective and learning outcomes along the societal, subject and student lines, suggests that such approaches can indeed be derived.

The purpose of this research is to investigate an appropriate evaluation methodology for BfCE pilot initiatives. To this end, a literature review has been carried out and the findings compiled into a generic framework for evaluation. This will contribute to the wider goal of a doctoral research project which seeks to determine how BIM can be leveraged to improve education in Architecture, Engineering, Construction and Facilities Management (AEC/FM) disciplines and to develop an effective BfCE module that enhances industry-relevant learning, increases students' motivation for (lifelong) learning and promotes this approach to teaching and learning.

We use the term "evaluation" here in relation to assessment and measurement as illustrated in Fig. 1 and described by Gandhi et al. (2017) thus: measurement is a construct that denotes giving a quantitative value to an attribute with no direction as to the impact of such quantitative value or interpretation of it. Assessment gives direction to the measurement without judgmental value while evaluation refers to a value judgement being applied to the assessment in order to inform action.

We acknowledge the broader purposes of evaluation which extend beyond students' academic performance (McCuen and Chang 1995) to the effect of the intervention on students' growth and behavioural output, educational decision-making, determining value in relation to resources invested, effectiveness of teaching/learning materials and techniques, encouraging and motivating students, etc. (Ogunniyi 1984).

Proponents of contextual considerations to evaluation such as Fry et al. (2015) argue that subtler considerations such as students' perceptions of the educator can also influence a students' attitude and performance in a course. The evaluation approach derived in this paper is intended to encompass all aspects of evaluation - achievement of learning objectives by students, content evaluation, delivery evaluation, learning environment evaluation, institutional impact evaluation/assessment, alignment of the learning content to industry needs, etc.

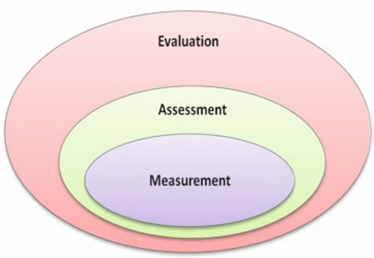

Fig. 1. Relationship between measurement, assessment and evaluation (Kizlik 2020)

This paper is arranged in five sections. The introduction is followed by a methodological description of the research approach which is a literature review. Findings are then presented followed by a discussion section in which an evaluation framework is proposed. A final section presents conclusions and recommendations from the study.

2 Approach

This research is part of a broader initiative in which an action research approach is employed for developing and testing the teaching of Construction Management topics within a novel, BIM-enabled education environment. Specifically, the action research methodology adopted follows a 4-step process of Diagnosing, Action Planning, Action Taking, Evaluation & Learning. For the present study, the focus is on the evaluation stage.

To establish the basis for evaluating the pilot BfCE action, a literature review was undertaken aimed at investigating existing guidance and experiences of evaluation of educational and training interventions. The review was carried out in two stages:

1. Reviewing the educational (non-research) guidance literature as well as articles in academic journals and conference proceedings to determine the suitability of existing evaluation models, whether evaluation of engineering education in a technologically mediated environment, at a topical level is feasible and the requirements for this type of evaluation.
2. Reviewing existing cases of BfCE reported in academic journals and conference papers to identify evaluation models and tools in use.

For the first stage, a Google Scholar search was carried out using the search term "evaluation of engineering education" anywhere in the text, in a search with no date restrictions but limited to English language sources. The search results were screened for relevance and a total of 24 sources (including textbooks, dissertations, journals, and conference proceedings) were selected for further content analysis using NVivo (v.12).

The second review drew on a comprehensive database of the BfCE cases reported in the academic literature which had been compiled in earlier research (Olowa et al. 2019). For this study, the cases contents were searched (using NVivo v.12) to extract all information pertaining to the evaluation models and tools used.

The results of these two reviews were then combined in order to derive a framework for evaluation to be applied in the evaluation stage of the wider action research.

3 Findings

3.1 General Evaluation Models

Evaluation models are specific frameworks or methodologies which assist evaluators in designing evaluation criteria and instruments. 15 examples of models were found in the literature (see Table 1: Evaluation models). Each model comes with its pros and cons and it appears that the criticism of any model may lead to the development of a new model. For instance, Illuminative evaluation model/ anthropological model was developed by Parlett and his colleagues (Stavropoulou and Stroubouki 2014) due to differences in ontological standpoints perceived in the Logic model of Weiss.

Table 1. Evaluation models

Evaluation model	Originator	Principles
	Edward Suchman	Evaluation as a scientific process
	Scriven	Need for both formative and summative evaluation
Countenance Model	Stake	Antecedents (innate abilities), Transaction (pedagogical intervention) and outcomes (products of the previous two). Emphasises evaluators' roles
Responsive Model	Stake	Level of involvement of educator
Context-Input-Process–Product (CIPP) model	Stufflebeam	Need for both formative and summative evaluation. External decision makers
Logic model	Weiss	Evaluation as a scientific process Level of involvement of educator
Illuminative evaluation model/ anthropological model	Parlett and Hamilton	Method of analysis Transparency in biases Flexibility/Rigidity
Utilisation-focused model	Patton	External decision makers

(*continued*)

Table 1. (*continued*)

Evaluation model	Originator	Principles
The teacher as researcher model	Stenhouse	Flexibility/Rigidity External decision makers
Connoisseurship model	Eisner	External decision makers
Goal-free and Goal-based model	Scriven	Flexibility/Rigidity
Case study model	Kenworthy and Nicklin	Flexibility/Rigidity
Process evaluation	Patton	Flexibility/Rigidity
Evaluation Planning Incorporating Context (EPIC)		External decision makers Flexibility/Rigidity
Balanced Score Card	Ho et al.	External decision makers
Outcome based evaluation (OBE)		Need for both formative and summative evaluation
Kirkpatrick's Model (four-step training evaluation)	Kirkpatrick	–

Sources: (Stavropoulou and Stroubouki 2014; Gordon 2018; Chinta et al. 2016; Anh 2018)

3.2 Processes in Evaluation Models

The models above include proposals for different steps or stages for the implementation of any evaluation exercise. The number of steps in the models are not uniform and they range from 3 to 10 steps or processes. Some models have their steps categorised into phases with each phase having sub-steps. For instance, the evaluation levels in Outcome Based Evaluation (OBE) are program, effectiveness, impact and policy while the framework levels in Kirkpatrick's Model are: Reaction, learning, behaviour and result. Furthermore, some authors argued that evaluation should not just be done at the end of a programme but should be comprehensive by starting right from the moment the programme is initiated (McCuen and Chang 1995).

3.3 Evaluation Models in Engineering Education

The literature reviewed suggested that the models in Table 1 above are not often explicitly considered in the evaluations of engineering education. Some authors have claimed the popularity of one or more of these models - for example, Anh (2018) stated that Stufflebeam's CIPP Model is widely used while McCuen and Chang (1995) opined that Kirkpatrick's Model is more common, but we found no evidence of this in our study even in relation to the evaluation of engineering education at programme or institutional levels.

A diverse range of methods of evaluating engineering education were found to be used by engineering educators for different purposes, lasting different periods, and involving varying complexities. Although most of the methods were not discussed fully by the authors, they include Accreditation Board for Engineering and Technology ABET, Baseline interview, longitudinal studies and portfolios, Web-based course for course evaluation questionnaires, Course panels and instructor reflective memos, QUESTE-SI (Quality system of European Scientific and Technical Education for Sustainable Industry), Student grades and SAPA (self- and peer-assessment). Many institutions ask their students for course feedback mostly by filling out questionnaires online which is used for general administrative purposes (for example see Palomera-Arias & Liu, 2016). This mode of data generation usually does not provide the information needed for effective course evaluation (id.). Somehow, the use of ABET seems understandable when applied to programme evaluation for it was designed for the purpose of accrediting engineering education (ABET, 2016b in Anwar et al. 2018). Whereas, QUESTE-SI on the other hand, which was initially designed for quality management in engineering education but at institutional and programme level now concentrates its attention on sustainability and environmental related issues though at the same level of application (Staniškis and Katiliute 2016). To what extent any of these methods could be applied to course and topical level of engineering education remain uncertain. Other methods applied at course levels are both for evaluation and assessment. Safe to recall that assessments carry with them no value judgement, to that extent Palmer and Hall (2011) adapted SAPA for course assessment. SAPA, the authors claimed could also be used for course evaluation. McCuen and Chang (1995) argue that evaluations based only on students' academic performance without contextual considerations such as the teaching style, institutional environment, teacher-student relationship, student-student relationship, classroom process and the general societal culture and values and which exclude the pre-implementation stages do not provide reliable evidence on what decisions could be made on intervention outcomes. Although this argument is the hallmark in the design of QUSTE-SI (Staniškis and Katiliute 2016), but its application is only at the institution or programme level.

Generally, engineering education seems to benefit only from the CDIO (Conceive – Design – Implement – Operate) standards, ABET, QUESTE-SI and other, educational board models. The developers of the CDIO in their justification for the supremacy of the model over other national and international standards e.g. UNESCO etc., claimed that it is more consistent, comprehensive and detailed. However, these standards or models are only applicable to programme wide application.

3.4 Evaluation in BIM Education

The second stage of the literature review considered evaluation models and tools reported in existing cases of BfCE. Out of 53 cases of reported BIM education activity, only 1 referred to any evaluation model at all and this was Comprehensive Assessment for Team-Member Effectiveness (CATME) for peer evaluation. 28 cases referred to the use of evaluation tools by BIM educators to assess the success or otherwise of their interventions. These are shown in Table 2 and include: (student/faculty/expert) interviews, questionnaire surveys, assessment rubric, test groups, student portfolios, focus groups and reflection.

Table 2. Evaluation in BIM education

Evaluation tool	Authors (cases)
Student feedback	Multiple authors/cases, e.g. Karshenas (2009); Peterson et al. 2011)
Questionnaire survey	Multiple authors/cases, e.g. Wong et al. (2011); Suwal and Singh (2018)
Assessment Rubric	Kim (2012)
Student Interview	Mathews (2013)
Questionnaire survey/Interview	Pikas et al. (2013)
Assessment rubric/questionnaire/interview	Kim (2014)
Informal discussion with students	Wang and Leite (2014)
Interview questionnaire of students, experts and faculty/test group	Park et al. 2016)
Questionnaire survey to industry experts	Clevenger et al. (2016)
Student survey/faculty reflection	Zhang et al. (2018)
student survey and focus group	ElZomor et al. (2018)
Student survey/student portfolio	Hu (2019)

The evaluation tools were also applied at different stages of the intervention. 6 out of the 28 cases of intervention in the study carried out a pre-implementation evaluation exercise, 5 conducted evaluation during the implementation of the intervention, i.e. formative evaluation (McCuen and Chang 1995), and all referred to post-implementation evaluations, i.e. summative evaluation (Ibid.).

The implementation stages of the evaluation tools varied among the cases. Some adopted pre-evaluation and post evaluation without formative evaluation during implementation. Others implemented formative evaluation during implementation with summative evaluation but with no pre-evaluation. Only one case (Clevenger et al. 2016) included evaluation at all 3 stages of intervention implementation.

The curriculum levels at which BIM education is carried out varied ranging from programme level to topic level. Only one case of programme and one of topic level curriculum implementations were reported with the remaining twenty-six cases referring to the implementation of new courses. At topic level, BIM-related learning is carried out within a course and the learning class session is usually between one and two. Course level involve dedicating a whole subject to BIM learning (usually with a course code) and/or relating BIM to the different aspects of other topics as they are offered in a subject (for example see Suwal and Singh 2018). Course level could also be a capstone project in which learners are required to exhibit the knowledge, skills and competencies that they have acquired over a certain period on a chosen academic project. BIM education at programme level involves introducing BIM education to the different academic levels in either a single or multiple discipline within the same department.

4 Discussion of Findings

The study found that the use of evaluation models in engineering education is generally low. In addition, little evidence of the use of evaluation models in relation to BIM education interventions was found with only one of the reported cases referring to any model at all being used in evaluation. This raises the questions: are models readily applicable in engineering education or in BIM education specifically? And, if so, is there a most appropriate model for engineering concept evaluation?

There are established evaluation models with similar process steps used for evaluating engineering education at institutional and programme curriculum level with only one for BfCE at course curriculum level and none at topic curriculum level. Noticeable is the prevalence of ad hoc models which are generally different from what are used outside engineering education. Methods and tools for evaluation are also diverse and the extent of knowledge sought by any of the methods is influenced by the subjective value of the evaluator or the educator.

Understanding the application of the models is an important prerequisite to their application under any circumstance for which they are anticipated, and even more understanding is needed if they are to be adapted. Whatever the choice of evaluation model to be adopted and/or adapted, there are merits and demerits associated with each. For this, evaluators are encouraged to weigh their purpose and balance it with the model anticipated.

Pre-implementation, implementation and post-implementation are the different stages at which evaluation could be carried out and authors, such as McCuen and Chang (1995), argue that evaluation should be carried out throughout the different evaluation stages (also advocated for post implementation even further long into the future after the intervention) to ensure maximum success of the exercise.

4.1 Development of BfCE Evaluation Framework

To inform the evaluation of our proposed BfCE intervention, we have attempted to draw together the key characteristics of the various evaluation models, tools and techniques reviewed. Figure 2 arranges these into 3 pillars of principles, process and tools on which a proposed evaluation framework in BIM for construction education (BfCE) is built. The principles relate to the main ideas behind existing evaluation models and include the axiological, ontological and epistemological values held by the educator that must be identified, acknowledged and consequently addressed for a robust evaluative outcome.

We have identified several principles that necessarily inform the implementation of evaluation in an intervention. These principles may be salient or unnoticeable and consideration of them would influence the choice of implementation process steps and how they are implemented.

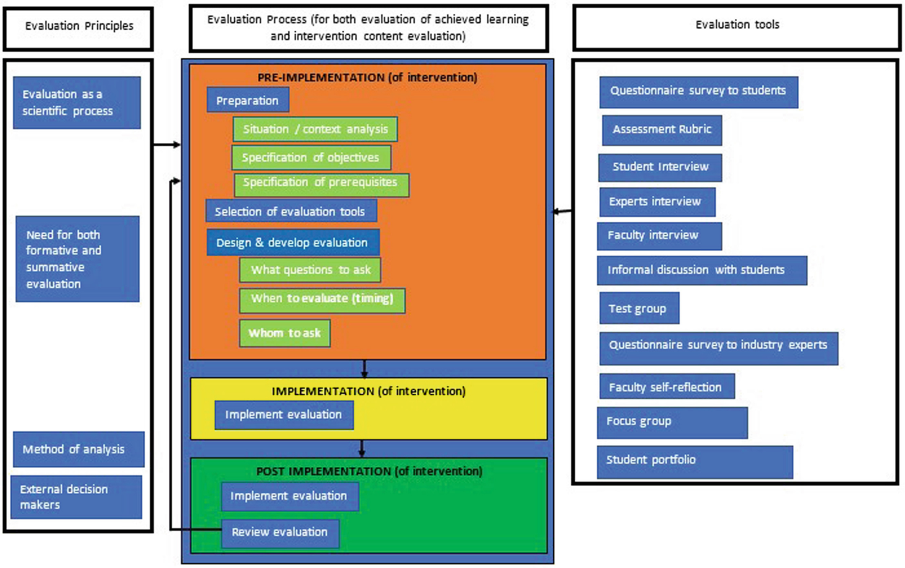

Fig. 2. Evaluation framework in engineering education

The implementation processes for evaluating BfCE (which could be for either one or a combination of content evaluation, delivery evaluation, learning environment evaluation and institutional impact evaluation/assessment) should include 3-broad stages for a rigorous and wholistic evaluation viz: pre-implementation, implementation and post-implementation. The first step of pre-implementation stage involves preparation activities such as situation and context analysis, specification of objectives and specification of prerequisites. The second step is the selection of evaluation tool(s). These tools (for example, questionnaire survey to students; assessment rubrics, etc.) could be used separately or combined in any suitable form to achieve the specified objectives. After the selection of the appropriate evaluation tool(s), the evaluation methodology can then be designed and developed in detail by asking the what, when and whom questions.

The second stage of the evaluation process is the implementation stage at which the pre-implementation decisions are carried out and implemented. If formative evaluation is required, then the educator or evaluator would constantly review the evaluation process at this stage for monitoring, control and possible improvement of the intervention environment and tool(s) for evaluation. However, the formative evaluation may be difficult to implement at topical level of intervention especially if the intervention is carried out over a single class session.

The third stage of the evaluation process is the post-implementation stage. This stage requires further implementation of the evaluation design and the review of both the second stage implementation and the third stage implementation. The post-implementation stage includes summative evaluation where the evaluation tool(s) designed and developed are administered at the end of the intervention for evaluation.

For the purposes of continuous improvement of the evaluation process, a review of the whole evaluation implementation should also be carried out to inform future evaluation cycles.

5 Conclusion

This study set out to investigate an appropriate evaluation methodology for BfCE pilot initiatives and interventions. Having reviewed and analyzed the extant literature on educational evaluation, evaluation models and approaches, in particular those related to engineering education, a framework for the evaluation of BfCE interventions has been derived to assist educators to evaluate their interventions. The proposed evaluation framework is intended to improve professionalism in the delivery of engineering education, and, specifically, improve the quality of BfCE implementations especially in universities. The benefits of utilizing a formal approach to evaluation are obvious, but further research is necessary to test its efficacy and outline in more detail the specific aspects of the methodology to make it more accessible and useful to potential users.

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Academic Maturity and Gender Differences in Students' Expectations from an ICT Study Program: A Survey

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Abstract. This paper presents a research on the criteria of students' satisfaction and their expectations from the study in the field of informatics and computing education. Constant changes and evolving environment in these STEM fields create various challenges and require continuous institutional adaptation and growth, as well as listening and monitoring students' expectations.

Authors conducted a quantitative research on all three years of bachelor study program in informatics, at the end of academic year 2018/2019. Students' attitudes regarding their satisfaction and expectations were tested using an anonymous survey. The survey tested students' opinions on the influence of the chosen criteria on overall satisfaction with the study. Special attention was paid to differences in the expectations between study years and differences in the expectations regarding students' gender. The main contributions of this paper are: a) a defined set of satisfaction criteria, b) insight into students' expectations from the study, c) influence of students' academic maturity on their expectations from the study and d) gender differences in students' expectations from the study.

Keywords: Survey · Student preferences · Study expectations · Higher education · ICT education

1 Introduction

In recent years, governments try to motivate research in the fields of science, technology, engineering, and mathematics (STEM) through projects and tenures. Students are also motivated to join STEM studies by scholarships offered to support them during their study and by a broad and rich future job offer. ICT (Information and Communications Technology) belongs to STEM field too, and in the ICT field one can notice the same trend, both in business and education. However, women and men are not equally present in STEM studies, nor ICT studies [1, 2]. This is the case especially in some parts of the world and countries that are less economically developed [3].

Authors' institution continuously monitors the share of female students in its studies. The entire bachelor study of informatics had all together 351 students (79 female students and 272 male students) enrolled in 2018/2019. This means that only 22,5% of students in this institution are female.

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Deeper analysis of these numbers shows that in the third year 40% students are female (38 out of 95). In the second year, this percentage is a bit lower, 25 out of 85 students are female, which makes 29,4%. But in the first year out of 92 students only 16 female students enrolled, i.e. 17,4%. These numbers show there is no gender equity in the number of students and the trend is getting worse. Motivated by these results, authors aim to detect students' expectations and satisfaction and possible gender differences, taking into the account students' academic maturity, as well, i.e. the year of their study. Knowing these data would help the institution to adapt the study according to factors that influence students' satisfaction the most, for female and also for male students. The research presented in this paper is focused on eleven criteria that might affect students' academic satisfaction. There were three main research questions: a) "What are the main students' expectations from their study program?", b) "Which criteria influence students' satisfaction the most?", c) "Are there any differences in students' satisfaction and expectations, regarding the gender and academic maturity?".

This paper is organized as follows. In the Related work section recent research and knowledge available in the literature are presented. In the next chapter motivation and methodology are presented. After discussion on research results, the final section offers conclusion and future work comments.

2 Related Work

It is important to understand students' satisfaction because it is a good indicator of quality assurance in the higher education system [4]. Previous research dealt with factors influencing students' academic satisfaction [5–7], and some research analyzed students' satisfaction specifically with engineering students [8, 9]. Also, there is a need for specific and additional attention on students' expectations and academic satisfaction in the field of informatics and computer science [10]. Criteria used in this research are selected after consulting relevant literature and are related to: student interest in course topics [11], overall impression of the school and overall impression of the quality of education [12] and factors concerning teaching and learning [13]. Additional criteria were partially defined on the basis of the authors' institution specific requirements and partially by individual approach to educational environment and existing circumstances.

Considering the relevance of the STEM field nowadays, as well as the general aim to raise the number of women in STEM field, this research tested students' expectations related to student's gender. It is noticed that female and male students have different expectations and pay attention to different factors recognized as important for students' satisfaction [14]. Chee et al. [15] noticed that female's grades on satisfaction can be more positively lenient than male students' grades. Research from Portugal shows that gender has a direct impact on students' expectations of university social responsibility, therefore universities should concentrate more on having sustainable and/or responsible campuses and relate academic education and research with social participation in order to support more humane, inclusive and sustainable development [16].

It is also important to understand students' expectations regarding the year of their study, because students might have different expectations depending on their academic maturity. Monitoring students' expectations is particularly important for the first-year students, because an insight into their thoughts at that moment offers enough time to adapt and align the study with their expectations [17]. However, universities should invest effort to retain students and monitor evolution of their expectations throughout the study [18–20].

Motivated by this knowledge, this research tested students' expectations from an ICT study program, depending on their academic maturity and their gender. The survey was filled in by students from all three years of bachelor study in informatics.

3 Methodology

Students' attitudes regarding their expectations from the study program were tested using a survey. A survey was distributed through an LMS to all three years of a bachelor study program in informatics in the academic year 2018/2019. It was completely anonymous and voluntary (some enrolled students did not participate). Of all the bachelor students that participated in the survey (N = 179), 35% were from the first year (19% female, 81% male), 30% from the second year (38% female, 62% male) and 35% from the third year (50% female, 50% male).

The survey consisted of 21 statements that were used to express students' opinions on the influence of the chosen criteria on overall satisfaction with the study. The chosen criteria are: study program, organization of the study, the content of obligatory courses, the choices of elective courses, the art and quality of informing, teaching style and teaching methods, grading style and grading criterion, availability of literature and learning materials, availability of IT resources, the possibility for acquiring practical competencies and quality of communication with teachers.

These criteria were chosen based on the University's standard annual alumni satisfaction questionnaire for which Department's results were slightly below the average results. The motivation for this study was to single out the criteria relevant for their satisfaction the most and to affect that criteria during their study in order to get higher results in the University's questionnaire. The survey results were both collected and semi-automatically processed through LMS Moodle with an additional use of Microsoft Excel.

4 Results

Results are presented in two parts. The first part deals with quantitative results regarding students' expectations, i.e. students' opinion about the influence of the selected criteria on their overall satisfaction with the study, shown by the year of study and gender. These results are shown in Table 1, Table 2 and Table 3. The second part deals with students' plans for their future and some possible factors of influence for seeking an employment abroad or in home country. These results are shown in Table 4 and Table 5.

The most relevant statements (those that are in the scope of this paper) are shown in Table 1. Students' attitudes were expressed using the following answers: Can't estimate, Disagree and Agree. The results are shown for the answers Disagree and Agree, by the year of study and gender.

Table 1. Influence of the criteria on overall satisfaction with the study

1st year		2nd year		3rd year	
Disagree % (F/M)	Agree % (F/M)	Disagree % (F/M)	Agree % (F/M)	Disagree % (F/M)	Agree % (F/M)
2. Avoiding lecture overlap is important for your overall satisfaction with the study					
0	88	0	92	0	100
–	(100/85)	–	(100/88)	–	(100/100)
3. Avoiding exam overlap is important for your overall satisfaction with the study					
0	100	0	100	0	100
4. Logical order of the courses is important for your overall satisfaction with the study					
0	88	0	92	0	94
–	(100/92)	–	(100/88)	–	(100/88)
6. The content of obligatory courses will influence your overall satisfaction with the study					
6	94	0	85	0	100
(0/8)	(100/92)	–	(80/88)	–	(100/100)
7. Choices of elective courses will influence your overall satisfaction with the study					
0	75	8	54	0	78
–	(100/69)	(0/13)	(20/75)	–	(88/63)
9. Teaching style and methods will influence your overall satisfaction with the study					
0	100	0	92	0	100
–	(100/100)	–	(100/88)	–	(100/100)
10. It is important for your overall satisfaction with the study to have practical exercises in small groups (up to 20 students)					
0	63	15	62	0	63
–	(67/62)	(0/25)	(60/63)	–	(75/50)
12. It is important for your overall satisfaction with the study to have practical exercises in large groups (more than 35 students)					
44	6	31	8	63	13
(0/54)	(0/7)	(20/38)	(20/0)	(75/50)	(13/13)
13. It is important for your overall satisfaction with the study that teaching includes field work					
13	56	15	38	0	94
(0/15)	(67/54)	(20/13)	(40/38)	–	(88/100)

(*continued*)

Table 1. (*continued*)

1st year		2nd year		3rd year	
Disagree % (F/M)	Agree % (F/M)	Disagree % (F/M)	Agree % (F/M)	Disagree % (F/M)	Agree % (F/M)
14. It is important for your overall satisfaction with the study that teaching includes individual problem solving					
13	56	8	54	13	69
(0/15)	(67/54)	(20/0)	(40/63)	(0/25)	(75/63)
15. It is important for your overall satisfaction with the study that teaching includes preparing seminar papers					
38	31	54	15	32	44
(33/38)	(67/23)	(40/63)	(0/25)	(38/25)	(25/63)
16. It is important for your overall satisfaction with the study that teaching includes e-learning activities					
6	33	15	77	0	94
(0/8)	(67/62)	(20/13)	(80/75)	–	(88/100)
17. Grading style and grading criterion are important for your overall satisfaction with the study					
0	100	0	85	0	94
–	(100/100)	–	(80/88)	–	(88/100)
18. Availability of literature and learning materials are important for your overall satisfaction with the study					
6	69	15	70	6	81
(0/8)	(33/77)	(0/25)	(40/75)	(0/13)	(88/75)
19. Availability of IT resources are important for your overall satisfaction with the study					
13	50	0	77	0	94
(33/8)	(33/54)	–	(80/75)	–	(100/88)
20. The possibility for acquiring practical competencies is important for your overall satisfaction with the study					
0	81	0	62	0	94
–	(67/85)	–	(60/63)	–	(75/100)

According to survey results, quality of communication with teachers and teachers' attitude towards students is very important criteria for students' satisfaction (from 92 to 100% of influence) and this is the same for all three years and for both female and male students. Teaching style and methods, as well as teacher's personality and attitude have a great role in achieving desired satisfaction level. Students highly value the organizational criteria - the effort of avoiding lecture and exam overlap and logical ordering of the courses throughout the study. As they mature through the study, they value more the avoidance of lecture overlap (statement 2), with female students giving higher importance to this criterion. As for the exam overlap (statement 3), it is of utmost importance to all students that participated in the survey, regardless the maturity or gender. Logical ordering of courses is important too (statement 4) – it grows in importance as students mature, but it is always a bit more important for female students. The importance of the content of obligatory courses is somewhat lower for second-year students but still pretty high. This can be explained with a difficulty level of the second-year curriculum (it is more demanding compared to first and third year). A general conclusion here is that students give high importance to quality and modern content of obligatory courses. Choices of elective courses (statement 7) are more important to first-year and third-year female students than male ones, but in the second year this is reversed. Related to this statement, students were asked about the number of elective courses they expect to be offered each semester and it can be seen that the expected number of elective courses grows as the academic maturity level increases.

First-year students mainly opted for 2 elective courses, with all female students saying so. Second-year students mainly opted for 3 elective courses, with more male than female students choosing this option. Second-year female students still expect 2 elective courses, as was the case in the first year of study. Third-year students mainly opted for 4 elective courses, with both male and female choosing this option. More details regarding students' answers on this question are shown in Table 2.

Table 2. Preferences on number of elective courses

No. of el. courses	1	2	3	4	>4
1st year	18	50	19	0	13
F/M	0/23	100/39	0/23	–	0/15
2nd year	15	31	39	15	0
F/M	20/13	60/12	20/50	0/25	–
3rd year	6	19	25	38	12
F/M	0/13	12/24	38/13	38/38	12/12

Related to statements 10 and 12, one can conclude that both female and male students of all study years prefer working in smaller groups and that they don't like large groups. However, in the third year there is a significant gender difference (female students have stronger inclination to small groups).

Related to the questions 13 and 14, students recognized the presence of field work and individual problem solving as important factors for their overall satisfaction with the study. The importance of both factors is the highest for third-year students, with field work being slightly more important to male students and individual problem solving being more important to female students. E-learning activities become more important too, as students mature through the study, with very small gender differences. Grading style and grading criterion are important as well, with them being the most important for the first-year students and with male students valuing this criterion slightly more than female do. Availability of literature and learning materials increase in importance too, as students mature through the study, with first and second-year male students valuing it higher. The same can be said for availability of IT resources, but second and third-year female students value this criterion slightly more. The

Table 3. Preferences on grading methods

Grading method	1st year Avg. priority (1–6)	2nd year Avg. priority (1–6)	3rd year Avg. priority (1–6)
Homework	2,81	2,69	3,50
F/M	1,00/3,08	4,00/1,88	4,00/3,00
Practical assignment	2,88	3,23	3,13
F/M	3,33/2,77	3,40/3,13	3,13/3,13
Midterm exams and tests	2,56	2,54	3,50
F/M	3,33/2,38	2,40/2,63	3,88/3,13
Seminar paper	3,75	4,23	3,44
F/M	2,67/4,00	4,20/4,25	4,50/2,38
Final exam	3,88	3,46	3,75
F/M	4,00/3,85	3,80/3,25	4,13/3,38
Oral exam	4,81	4,77	4,56
F/M	6,00/4,54	4,60/4,88	4,13/5,00

possibility for acquiring practical competences is somewhat inconsistent: first and third-year students value it high, but second-year students give it only 61%. This can again be explained with a complexity of the second-year curriculum, when they don't have spare time in curriculum to think about professional practice. Male students value this criterion more than female, consistently in all the study years.

Students' opinions regarding seminar papers (statement 15) are divided – it seems that preparing a seminar paper is not so relevant for their overall satisfaction with a course/study. The second-year students even say they don't favor preparing seminar papers. Considering gender differences, female students favor preparing seminar papers more in the first year of study, but in the third year the situation is reversed.

Related to statement 17, students were asked to prioritize grading methods according to their preferences, where grade 1 was "I prefer it the most" and grade 6 was "I dislike it completely". Average grades for each grading method by the year of study and gender are shown in Table 3.

According to the results, students favor the most midterm exams, homework and practical assignments. First-year male students favor homework more than female ones, but the situation is reversed in other two years. Practical assignment is favored the most by first-year students and midterm exams by first and second-year students. The only difference here, considering gender, is for the first-year students where female students favor these two grading methods slightly more.

Oral exam is the most disliked grading method in all three years of study, with first-year female students disliking it the most. However, a small decreasing trend can be noted – as students mature through study, they seem to dislike this grading method less. Seminar paper remains the issue on which students are divided. Second year students dislike it the most (both female and male), but the situation is not so bad in the first and third year of study – they seem to like it the most in the first year (female students especially). As for the final exam, female students favor it less than male ones, in all three years of study.

To get insight into students' plans for the future, they were asked to prioritize their plans according to their preferences, where grade 1 was "Most likely" and grade 6 was "Least likely". Average grades for each plan by gender and year of study are shown in Table 4.

Data show that after finishing their bachelor study students plan to continue their master study at the same institution. They don't plan to enroll master study at some other Faculty/Department of the same University or to move to some other university. However, second-year students are considering these options the most, but this can also be explained by the difficulty level of this year's curriculum. As for looking for employment in or outside of their home country female students favor staying and working at home, and male students favor looking for employment abroad. Interestingly, as students mature through the study, they favor less the idea of starting their own business.

Migration for employment is recognized as a very serious problem in Croatia. Since this is a country which recently entered European Union and now has more options for Croatian workers to migrate, this institution was highly motivated to recognize the reasons which influence the most students' decision to leave their homeland. Students were asked to prioritize possible factors of influence for staying at home or going abroad. Grade 1 was "Most affecting this decision" and grade 7 was "Least affecting this decision".

Average grades for each reason, presented by gender and year of study, are shown in Table 5. According to the results, students state the main reason for seeking an employment abroad is the salary, followed by general quality of life and more opportunities for advancement.

Table 4. Students' plan for the future

Plan for the future	1^{st} year Avg. priority (1–6)	2^{nd} year Avg. priority (1–6)	3^{rd} year Avg. priority (1–6)
To look for employment in Croatia	2,56	3,15	2,31
F/M	1,00/2,92	3,00/3,25	2,13/2,50
To look for employment outside Croatia	3,63	3,46	3,56
F/M	4,67/3,38	4,00/3,13	3,63/3,50
To enroll master at the same Faculty/Dept	2,63	2,77	1,88
F/M	3,00/2,54	3,40/2,38	1,75/2,00
To enroll master at some other Faculty/Dept. at the same University	5,19	4,38	5,00
F/M	4,67/5,31	4,40/4,38	5,63/5,63
To enroll master study at some other university	4,63	3,38	4,13
F/M	4,33/4,69	3,20/3,50	4,50/3,75
To start your own business	3,31	3,85	4,19
F/M	4,67/3,00	4,20/3,63	4,13/4,25

Female students especially believe the quality of life is better abroad, but they are also less critical than male students to the quality of life in Croatia. Also, as students mature through the study, having better opportunities for job advancement and better working conditions become more important reasons for migration. All students believe the main reason for staying home and seeking employment in Croatia is the vicinity of family and friends – but especially first-year students. Interestingly, more female students in the first and second year believe so, but in the third year this is reversed. Most students think the choice of jobs in IT industry in Croatia, as well as salaries and opportunities for advancement, are not sufficient. First-year students gave the worst grade to choice of jobs, and third-year students gave it to salary. Female third-year students are especially critical to both criteria. As students mature through the study, they believe working conditions and work atmosphere become less important reasons for staying in Croatia.

Table 5. Factors of influence for seeking an employment abroad and at home

Abroad			At home		
1st year Priority (1–7)	2nd year Priority (1–7)	3rd year Priority (1–7)	1st year Priority (1–7)	2nd year Priority (1–7)	3rd year Priority (1–7)
Choice of jobs (F/M)					
2,94	3,15	2,94	4,25	3,69	3,94
(2,67/3,00)	(2,20/3,75)	(2,88/3,00)	(4,33/4,23)	(3,60/3,75)	(5,00/2,88)
Salary (F/M)					
1,88	2,46	2,06	3,63	3,31	4,44
(1,67/1,92)	(2,60/2,38)	(2,13/2,00)	(3,67/3,62)	(3,00/3,50)	(5,25/3,63)
Opportunities for job advancement (F/M)					
3,31	2,85	2,75	4,00	3,69	4,38
(3,00/3,38)	(2,40/3,13)	(2,50/3,00)	(4,33/3,92)	(3,20/4,00)	(4,75/4,00)
Working conditions (working hours, distance from work, …) (F/M)					
4,06	3,00	2,69	2,44	3,31	3,56
(4,00/4,08)	(2,20/3,50)	(2,13/3,25)	(2,33/2,46)	(2,40/3,88)	(3,25/3,88)
Employer's attitude to employees/work atmosphere (F/M)					
4,00	2,54	2,78	3,06	3,46	4,38
(4,33/3,92)	(2,00/2,88)	(3,13/2,88)	(3,00/3,08)	(3,20/3,63)	(4,50/4,25)
Professional development (F/M)			Vicinity of family and friends (F/M)		
3,63	3,15	3,44	1,63	3,15	2,00
(4,00/3,54)	(2,80/3,38)	(3,13/3,75)	(1,33/1,69)	(2,00/3,88)	(2,50/1,50)
Quality of life (F/M)					
2,06	2,31	2,19	3,31	3,69	3,25
(1,00/2,91)	(2,00/2,50)	(2,00/2,38)	(2,67/3,46)	(3,00/4,13)	(3,13/3,38)

5 Conclusion

In this paper a research on the students' expectations from the study in the field of informatics was presented. Students' attitudes regarding their satisfaction and expectations were collected using an anonymous survey, in the year 2018/2019. The survey tested students' opinions on the influence of the chosen criteria on overall satisfaction with the study. A possible limitation of the survey is the fact that it was designed based on external, standard and predefined question set used in University's general satisfaction questionnaire.

Special attention was paid to differences in the expectations regarding academic maturity and gender. The main contributions of this paper are: a) a defined set of satisfaction criteria, b) insight into students' expectations from the study, c) influence of students' academic maturity on their expectations from the study and d) gender differences in students' expectations from the study.

Research results show that academic maturity and gender both influence students' opinions on some criteria, but for some attitudes these are the same, regardless of gender and/or academic maturity. Quality of communication with teachers, teaching style and methods, exam overlap avoidance and working in smaller groups are perceived positively from all students, while oral exams are generally disliked.

Furthermore, academic maturity is related to their preferences of: avoidance of lecture overlap, logical order of courses, number of elective courses and having e-learning activities in courses. Also, importance of availability of literature, learning materials and IT resources increases as students advance through the study.

Some criteria such as grading style, grading criterion and the possibility for acquiring practical competences are more important for male students, while female students value study organization in general (lecture, exam overlap, ordering of the courses) more.

Academic maturity and gender shape their opinions on possible migration for employment. As students get closer to graduation, having better opportunities for job advancement and better working conditions become more important reasons for migration. On the other hand, both genders think the quality of life is better abroad, but the percentage is higher in female students. However, female students are also less critical than male students to the quality of life in Croatia.

For a number of criteria, the results from second-year students are inconsistent with the others. This can be explained with the content of second-year curriculum which is more comprehensive and demanding than in the other two years. Academic pressure on these students is higher and their priorities are slightly different during that period.

This research gave answers and discussion to the set research questions about students' expectations from the study program, criteria that influence students' satisfaction the most and differences in students' satisfaction and expectations, regarding the gender and academic maturity.

Further research includes continuous monitoring of students' expectations and attitudes towards both bachelor and master study programs, teaching and academic environment. Authors aim to expand their research with additional criteria that could have further and deeper impact on students' satisfaction. It would be useful to compare students' attitudes with those from similar studies in other parts of Europe. Finally, it would be interesting to analyze students' success rate considering gender and find what motivates them to finish the study in time and with better grades.

In any case, the results of this and future research will be considered when designing new study programs, reshaping the current ones and creating institution's long-term strategy. It will be useful to see what needs to be changed in order to, for example, make the study program more attractive to female students.

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Remote Technical Labs: An Innovative and Scalable Component for University Cybersecurity Program Admission

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Abstract. In response to the existing and predicted skills gap in cybersecurity, educational institutions establish an increased number of studies. Admission boards need to screen large numbers of applicants to identify those with the highest probability of successful completion. To address the current lack of scalable and validated admission procedures with predictive value, we present a validation of an innovative university admission process for a master level program including technical skills assessment via cloud-based virtual labs. A regression model based on data collected during admission assessment procedures is applied to predict later study performance in technical courses. The virtual labs assessing technical skills but also interview component had comparably high predictive values for study performance, indicating a complementary relationship of two distinct skill-sets. The primary conclusion of this research is that cybersecurity technical labs can be used to significantly improve the predictive value of traditional interview-based admission processes for the candidates' later success in technical courses.

Keywords: Cybersecurity · Exercises · Predictive analytics · Technical skills

1 Introduction

Cybersecurity professionals need to be trained on a variety of skills including identifying cyber threats and vulnerabilities, protecting information and resources, detecting, responding and recovering from cybersecurity events, etc. [5,25]. To meet the labour market's demands, academic institutions have established dedicated programs to train more specialists [5]. A variety of admission processes are in place aiming to select candidates of high quality and low dropout

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probability. To ensure effectiveness, transparency, and the possibility of further development, any such selection process should be scalable and validated. To date, systematic validations of admission processes are scarce. Traditional knowledge-based assessments for technical skills may fail to detect high potential candidates, who fail to provide declarative knowledge at the time of assessment due to their interdisciplinary background [21]. We argue that an accurate assessment of study potential needs to assess technical skills and knowledge using knowledge questions and hands-on tasks in addition to interviews to assess learning capacity in an ecologically valid assessment procedure.

In the admission process to the international Cybersecurity masters program (MSc), we have used online interviews and technical assessments in addition to traditional admission procedures [21]. Currently, the technical assessments—Intro, HTTPS Security, SQL Injection and Botnet labs—are optional. We aim to demonstrate that the admission's technical assessment component is an accurate predictor to rank the candidates for cybersecurity studies and that this can predict their success in the technical cybersecurity subjects. As a result, the practical technical assessment tapping into learning potentials rather than pure pre-existing knowledge, may then replace less reliable technical questions during the interview. We use Cybersecurity Technologies (CST), a mandatory course for first year MSc students, to evaluate the technical skills in admission and in later studies. As the lab exercises focus on assessing the technical competencies, we leave the assessment of non-technical skills, which are at least equally important, to other validation methods.

We address following research questions (RQs):

- RQ1: Can admission procedure including the technical online labs on selected cybersecurity topics predict the students' performance in the technical subjects in the university curriculum? Is it a more accurate predictor than the admission interview component?
- RQ2: Do more comprehensive and complex cybersecurity technical assessments used at the beginning of the course predict student performance? Is this assessment appropriate as the basis to assign the students to the courses with different difficulty levels?
- RQ3: Is more comprehensive assessment necessary at the beginning of the course, or can the results of selected technical labs used during admission procedure also predict the students performance?

We analyse admission process and CST course completion data to model the prediction of the students' success applying a linear regression model. The model's main purpose is to statistically validate whether the novel use of virtual technical labs on varied cybersecurity topics is a significant predictor to measure candidates' technical skill level during their later studies in this core subject of cybersecurity technology. The results indicate that such methods to predict student performance with limited set of input data from the labs in the cybersecurity domain can be indicative. We also describe the data and evaluation method in sufficient detail to replicate the research and CST course design to assist in developing cybersecurity curricula.

2 Research Design

The first-year course are used for performance prediction in order to minimize impact of other variables in a student's academic life. We also evaluate whether the complex and comprehensive skill assessment conducted during the first CST lecture predicts students' later study performance more or less accurately than the admission labs. This in turn validates that the admission labs are relevant and predict the students' success in the cybersecurity technical subjects at an early time point critical for admission selection. Pearson's bivariate correlations are used for correlational analysis of parametric variables [4]. Kendall's Tau is used to analyse non-parametric measures of relationships between columns of ranked variables (value of 0–no relationship or 1–relationship) [11].

2.1 Ethics, Privacy Data and Data Security

Aiming to scale the university admission process by incorporating the technical online labs raises a variety of ethical implications. An aim of this research is to reduce sole dependence on the decisions of human interviewer and course instructor by adding an additional component of evaluating the skills using the technical labs. Ethical considerations such as fostering trust, transparency, student control over data, right of access and accountability [24] are followed. The labs completion in the admission is voluntary, the applicant/student receives the results automatically. The role of the labs is described as being a part of the admission process and the course grading. Also, as online or digital interactions produce a data trail of a person's activity, privacy and data security aspects are important. We have pseudonymised the data with unique identifiers to ensure the privacy of individuals. The data was stored on the university' server, with access to the research material is restricted to only the some of the authors and selected university personnel directly associated with this study and admission process.

3 Related Work

One purpose of assessments during admission processes is to early distinguish between students who are likely to perform well or drop out [23]. Prediction modeling in the university admissions (including in Science, Technology, Engineering and Mathematics (STEM) disciplines) frequently used. A meta-analysis of academic literature on the prediction of student performance in computing courses is described in [14] summarising 357 articles. This review shows the relevance of predictors such as GPA, demographics, learning behavior data, etc. [14]. However, there is a gap of knowledge regarding the use of technical online labs as part of admission assessment and performance prediction in cybersecurity programs. Most prediction models require knowledge of previous performance or are mainly based on demographic data (e.g., [7,10,18–20]). However, in global assessment procedures such information may not necessarily be available, reliable, or comparable and admission decisions thus include limited or incomplete data. Prediction models not relying on legacy data do usually not address gamified technical exercises as a relevant predictor for future learning success ([16]). [22] categorizes methods used for predicting performance into four high level categories: Decision trees, Regression, Clustering, Dimensionality reduction/other. [17] suggests choosing multiple linear regression models when predicting the average academic performance. [18] uses past performance data and applies a decision tree algorithm to identify students who are likely to fail in advance. Other methods include Logistic Regression, Decision Tree, Random Forest, Naive Bayes and Adaboost models [1,9,10,13,19]. We apply a multiple linear regression model and leave comparison with other modeling methods as further work.

In cybersecurity, [3] describes a recruiting tool that provides an 8-hour training and competition framework. This approach requires significant time commitment from faculty and students as it is designed as live learning event. [8] proposes a model for predicting cybersecurity aptitude beyond a general-intelligence approach, where the constructs of tasks, work roles, and people can be used to create assessments of applicants. However, a general intelligence assessment is very time-consuming, may not tap into the relevant skills related to the technical tasks in focus and do not require additional efforts over time (motivational aspects) that virtual technical labs offer. In cybersecurity, there are few examples of student modeling, such as [6] using log data to predict course grade, [15] predicting team proficiency, [2] assigning specific exercise in accordance to preparedness, [26] analysing learning activities (reading lab materials and working on lab tasks) association with students' learning performance in a course. However, these papers do not build prediction models in context of admissions with limited data.

This paper builds upon the previous work described in [21].

4 Admission Process and Study Program/Technical Courses

We provide an overview over the study program, the technical labs used in the admission process, the CST course and an overview of the data collected and used in the prediction model.

4.1 Cybersecurity Masters Program

The cybersecurity curriculum consists of general studies, core studies, special studies, free choice courses and graduation thesis. During the studies the students have to choose a specialty—Cybersecurity, Digital Forensics or Cryptography. All specialities require completion of general studies, core studies (Cybersecurity Defence Technology), a selection of free choice courses, specialty courses and a master's thesis.

4.2 Admission's Technical Labs and Interview

The detailed overview of the admission process and all its components is presented in [21]. To apply a feasible selection of the many possible cybersecurity skills in the admissions, the technical exercises represent topics from basic to advanced skill levels as follows:

- Introduction lab (25 min)—essential command line skills (Git, apt-get, Apache server);
- HTTPS Security (45 min)—basic level skills connected to command line, public key infrastructure, and server administration basics;
- SQL injection (90 min)—intermediate level skills connected to attacking SQL databases (SQL, SQL injection); and
- Botnet (45 min)—advanced level skills connected to network scanning skills, text parsing (programming skills are beneficial) and SQL injection skills.

The choice of these labs is based on typical attack vectors that the applicants are likely to encounter in their future cybersecurity jobs and require different skill levels (from essential to advanced). Each lab represents a pre-determined skill level from basic to advanced [21].

Interviews last usually for 10–15 min. The interviews includes few technical questions, which aim to measure the candidate's knowledge and logical thinking [21].

4.3 Cyber Security Technologies

The CST's learning objective is to provide a coherent understanding of technology (theory) and provide a hands-on learning (experiential learning). The main focus is on the tools and methods for securing networks, operating systems and web applications.

CST1 and CST2. CST is split into two sub-courses, Cyber Security Technologies 1 (CST1) and Cyber Security Technologies 2 (CST2). While both courses follow the same study plan, CST1 is aimed towards beginners and CST2 for advanced students who are already familiar with cybersecurity technologies. All students must attend either course version in their first study year.

Students in CST I are introduced the topics related to the fundamentals of networking, information security and cybersecurity. Students learn about the different types of technologies with the learning objective to understand when and where these tools should be utilised, and how to configure and deploy specific tools to their own environment. CST2 requires a programming, system administration or information security background and basic knowledge in networking, operating systems and web applications. If students from CST2 feel they do not have enough knowledge on a certain topic, then they are free to attend CST1.

Initial Assessment to Assign Students to CST1 or CST2. To determine whether a student is assigned to CST1 or CST2, a mandatory skill assessment exam is given in the first lecture. Students complete a “WASE Assessment”, which is 180 min long complex virtual lab where an individual has to investigate a website and try to regain control. Students have to know various types of web application vulnerabilities and how to exploit them (web-servers side, incl. SQL authentication bypass, reconnaissance, privilege escalation, command injection, path traversal, blind SQL injection, etc. and web-client side, incl. reflected, stored and DOM based XSS, session hijacking, CSRF, etc.). The requirements of this test are high to avoid ceiling effects. The relevant outcome variable is the progress made within three hours.

Course Assignments. The course is designed as a combination of theory and hands-on exercises aiming to challenge the students along the way with different assignments as milestones rather with one final exam. The assignments consist of group work, home labs, individual tasks, discussions and online hands-on technical assessments, see Table 1. Groups (consisting of 4–6 students) are self-formed and all group works are completed with the same group.

Table 1. Course assignments in CST1 and CST2

Assignment	CST 1	CST 2
Individual Assignment	Malware Lab	Malware Lab
Individual Assignment	Quiz	Vulnerability Testing
Group Work 1	Security Principles	Company X-Part 1
Group Work 2	Information Gathering and Vulnerability Testing	Company X-Part 2
Group Work 3	Authentication and Access Control	Company X-Part 3
Group Work 4	Logging and Log Analysis	Company X-Part 4
Online Technical Test	SOC-Security Compromised	SOC-Security Compromised
Group Work 5	Certificates and Public Key Cryptography	Company X-Part 5
Group Work 6	Risk Management	Company X-Part 6

5 Data Collection, Cleaning and Integration

The data originate from multiple sources, see Table 2. The unstructured data was converted into structured data by removing irrelevant information (i.e., duplicated data if student attends both courses, not enrolled at MSc program, registered but not taking CST, is not 1st year student), verified and pseudonymized. For correlation analysis, the data was integrated into one data-set, also newly aggregated/calculated fields were added named “Ranks”. Descriptive statistics are presented in Table 3. The admission and course results of 60 students are included in this analysis.

Table 2. Data collected and used in prediction model as variable

Field Name	Value	Unique data values	Description
Student Name	Firstname.Lastname	60	An identifier to integrate data together from different sources. Once each student receives an ID number, this field is removed
Student ID	Student 0X	60	Each student is identified with an ID number from 001
Course	(1) Beginner (2) Advanced (3) Advanced/Beginner	3	3 unique values: students eligible for CST2 are classified as advanced, students eligible for CST1 are classified as beginners, students eligible for CST2 but take both courses are classified as advanced/beginners
Admission Interview Score	50–100	60	Admission interview results, minimum threshold to accept candidates into the program is 50 points
Admission Online Technical Assessment Score	0–400	59	Admission Technical assignment results —4 different labs, each worth up to 100 points
Assignment 1 Lab Results	0–100	60	First assignment is identical for both courses; students are expected to accomplish this individually at home. Task is to analyse 3 malware samples, answer questions and write report. This is same task for both courses and can be used to measure student performance, regardless of course enrollment
CST1 Individual Assignments	0–400	52	Aggregated results of all individual assignments for CST1
CST1 Group Works	0–600	52	Aggregated results of all group assignments for CST1
CST1 Course Total	0–1000	52	Aggregated results of all assignments for CST1
CST2 Individual Assignments	0–200	11	Aggregated results of all individual assignments for CST2
CST2 Group Works	0–300	11	Aggregated results of all group assignments for CST2
CST2 Course Total	0–500	11	Aggregated results of all assignments for CST2
WASE Assessment Score	0–150 000	60	All students have to complete WASE Assessment in order to be assigned to CST1 or CST2. As all students complete this– data can be used to measure and compare student performance
SOC-System compromised Progress	0–100	60	Online assessment, that all students have to complete in class, regardless of course enrollment
SOC-System compromised Duration	0–5	60	All students are encouraged to finish the lab, therefore measuring progress is redundant as most get 100% score. Time to complete assessment is more relevant metric—this can be used to compare students' understanding the problem and how fast they can solve it

Table 3. Descriptive statistics of data

Data	Mean	Median	Min	Max	Standard Deviation	Range
Admission Labs Results	280.2	293.0	0	400	117.8	400
Admission Interview Results	73.90	77.25	50	97.5	12.09	47.5
WASE Assessment	32 000	20 000	0	150 000	40 497	150 000
Lab 1	89.5	100	0	100	26.32	100
System Compromised Points	85.05	100	0	100	32.7	100
System Compromised Time	1.9	2.07	0	4,42	0.98	4,42
CST 1 Individual Assignments	249.1	268.3	0	310	63.15	310
CST 1 Group Assignments	354.13	380	0	400	91.76	400
CST 1 Course Total	687.9	739.05	81.25	845	160.74	763.75
CST 2 Individual Assignments	175	200	0	200	60.2	200
CST 2 Group Assignments	189.1	190	170	200	10.44	30
CST 2 Course Total	473.2	490	300	590	68.3	290

6 Results and Discussion

6.1 RQ1: Admission Labs and Later Success

We used Pearson's one sided correlation test method to account for the directed hypotheses that admission and CST-performance are positively related. The variables of course performance, admission interview rank, admission technical assessment rank and admission rank were added to the correlation matrix, see Table 4.

Table 4. RQ1: Pearson's one sided correlation test

Course Performance	Admission Interview Rank	Admission Lab Rank	Admission Rank
Pearson's r	0.378	0.432	0.492
p - value	0.005	0.001	<.001

There is a positive correlation between the admission assessments and the later course performance, while the strongest positive correlation is between "Course performance" and the resulting "Admission Rank" combining both interview and virtual lab results.

Admission interview and technical results are added to a stepwise regression model with predictor variables interview and remote labs and course performance as the dependent variable, see Table 5. In Model 1, course performance is used as dependent variable and admission interview rank as only predictor. Model 2 adds the remote lab result as additional predictors.

Table 5. RQ1: Admissions and course success linear regression model

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
1	0.378	0.143	0.126	14.448	0.143	8.507	1	51	0.005
2	0.495	0.245	0.214	13.700	0.102	6.727	1	50	0.012

The assessment technique interview is in itself a statistically significant predictor for later student performance and explains .126 = 12.6% of Student performance variance. Adding the additional predictive effect of the virtual lab, the explained variance in study performance almost doubles from 12.6 to 21.5%. This significant increase ($p = .012$) means that interviews and labs are complementary methods that both predict different, but relevant, aspects of the later student performance results as measured in CST courses. The results for ANOVA test are presented in Table 6.

Table 6. RQ1: ANOVA test

Model	Model type	Sum of Squares	df	Mean Square	F	p
1	Regression	1775.822	1	1775.822	8.507	0.005
	Residual	10646.291	51	208.751		
	Total	12422.113	52			
2	Regression	3038.279	2	1519.139	8.094	<.001
	Residual	9383.834	50	187.677		
	Total	12422.113	52			

Relationships between the predictor variable and response is shown in Table 7. The standardized betas show the relative weight of the predictors. The single standardized betas are low to moderate, but provide a highly significant predictive value when combined. The predictors' scores are medium correlated with each other, which means that the interview scores and technical skills assessment via virtual labs share both common factors and relevant unique variance. For example, attitude, eagerness and technical interest are checked in the interview process but are also relevant for the technical performance. An explained variance of 21.4% is considered to be large in behavioral science convention [12].

Table 7. RQ1: Relationships between predictor variable and response

Model		Unstandardized	Standard Error	Standardized	t	p
1	Admission Interview Rank	0.340	0.117	0.378	2.917	0.0005
2	Admission Interview Rank	0.231	0.118	0.257	1.955	0.056
	Admission Technical Assessment Rank	0.246	0.095	0.341	2.594	0.012

6.2 RQ2: Complex Assessment at Course Start and Later Success

To evaluate whether WASE assessment predicts student performance and in turn assign students to appropriate CST course, we used Kendall's Tau B testing method. From the model output we see that Kendall's Tau B coefficient is 0.502 and p-value $\leq .001$. There is a strong positive correlation between WASE assessment and course performance. This indicates that WASE assessment is a valid predictor of the students' performance. This also indicates that the students have been assigned to the correct CST course.

6.3 RQ3: Admission Labs Vs. Complex Assessment and Later Success

To evaluate whether a WASE assessment is necessary or admission lab results could be used to assign students on CST1 and CST2, we used Pearson's one-sided correlation testing method because there is directed hypothesis that WASE assessment and CST-performance are positively related.

Table 8. RQ3: Pearson's one-sided coefficient

Course Performance Without WASE	Admission Interview Rank	WASE Assessment Rank
Pearson's r	0.329	0.548
p - value	0.016	.001

A significant positive correlation between the input and admission interview rank is evident, see Table 8. However, the correlation between course performance and WASE assessment rank is stronger with the correlation coefficient 0.548. When using stepwise regression to further explore the relationship between course performance, admission result and WASE assessment, we can see that course performance without WASE assessment is dependent variable and "Admission technical rank" and "WASE assessment rank" are predictor variables.

Table 9. RQ3: WASE and technical assessment linear regression model

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
1	00.322	0.104	0.086	14.727	0.104	5.890	1	51	0.019
2	0.551	0.304	0.276	13.106	0.200	14.401	1	50	<.001

Looking at the linear regression model in Table 9, the admission technical lab results significantly (.019) predict the student performance and explain $.086 = 8.6\%$ of performance variance. This means that interview in its own is a valid predictor for assigning students into correct CST course. However, when adding WASE assessment then R square is 3 times higher from 8.6 to 27.6. This increase is significant ($p = .001$), which means that the two variables are complementary methods that both predict different aspects of the student performance.

Table 10. RQ3: Relationships between predictor variable and response/coefficients

Model		Unstandardized	Standard Error	Standardized	t	p
1	Admission Technical Rank	0.231	0.095	0.322	2.427	0.019
2	Admission Technical Rank	0.047	0.098	0.066	0.484	0.630
	WASE Assessment Rank	0.543	0.143	0.516	3.795	<.001

Relationships between the predictor variable and response is shown in Table 10. The combined weight of the predictor scores are relatively highly correlated, which means that the admission technical assessment and WASE assessment have common factors. The correlation is relatively high, which means that both methods contribute also individually and unique parts that predict the student performance score. Overall, WASE assessment has a stronger correlation with student performance.

7 Future Work

As future work, validation of the hands-on technical exercise tasks by correlating it with general intelligence, other cognitive skills, and domain-specific knowledge is suggested. This will improve our understanding for what is tested in this task (construct validation). A longitudinal study with new students and larger sample size will be continued to validate and refine the algorithm. In addition, as we applied multiple regression model, the comparison with larger datasets and other prediction modelling methods would be beneficial.

8 Conclusion

We evaluated using technical labs as a novel part of graduate level admissions for cybersecurity program, to predict students' later success in studies. Such an approach can be a scalable evaluation of technical skills, but still incorporate human evaluation to enable balanced approach for the ethical and evidence-based decision making and assessment. While the labs used in this paper are specific for the technical skills for a cybersecurity program, incorporating this type of assessment may also spark interest in other STEM programs.

While we acknowledge that this analysis is an initial attempt with relatively small sample size to assess whether such technical skill labs can be used as a significant predictor to assess potential candidates' skill level and future study success in technical topics, is shows some promise based on the regression analysis. This analysis however also shows that the interview score is not redundant either—both admission methods are complementary to each other addressing different, but equally relevant aspects of the student performance.

In addition to the prediction model, we shared our experience and description of the admission process and Cyber Security Technologies course design.

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A Method for Generation of Multiple-Choice Questions and Their Quality Assessment

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Abstract. The purpose of this study is to propose a reliable multiple-choice or multiple-response assessment generation procedure. A question of the assessment passing threshold selection is considered. The study uses simulation for the test outcomes distribution evaluation which is used for the assessment passing threshold calculation. The relation between the number of answers and distractors in a task and assessment reliability is shown. The reliable assessment generation procedure based on simulation and statistics is proposed. The web application for students testing purposes based on the proposed approach is implemented. The proposed method can be used for online studying as well as offline ones.

Keywords: Multiple-choice assessment · Multiple-response assessment · Online assessment · Simulation modeling

1 Context

Online multiple-choice tests, as well as multiple response tests and questions, show significant growth last few years due to the wide spreading of massive open online courses [2,9]. It becomes even more important at the moment because of the coronavirus pandemic [6].

In the case of a remote learning situation, it is important to develop a cheating-proof and fair assessment procedure.

The vital parameter of multiple-choice tests and multiple response questions is their discrimination abilities, in other words, the ability to divide the testees into two groups, the ones who have enough knowledge, and the ones who don't. It is also good to grade testees, to evaluate the knowledge level of a testee in comparison to the others. There are a lot of works devoted to designing good in some sense assessments [8,11].

Using the percentage of correct answers given by a testee during the assessment procedure as a measure of testee's knowledge, abilities and skills require a method to set up the correct threshold that divides testees into the ones who successfully passed the assessment and the ones who don't.

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2 Purpose

The main aim of an assessment of a testee is to determine the abilities of the testee we assess to act at a given level of Bloom's taxonomy [5]. As it was already mentioned, the assessment is a means to divide the testees into the two groups: the ones who have the required abilities, and the ones who haven't. It is also good to have the means to compare the abilities of the testees who passed the assessment, in other words, to range the testees according to their knowledge, skills, and abilities level.

It is also important to prevent cheating during an assessment. According to if we perform the assessment online or offline using computer means, the ways to prevent cheating can be different, but there are means to reduce the cheating no matter which kind of assessment we use.

It's obvious that passing any multiple-choice question, as well as multiple response questions, is a probabilistic procedure, and both false positive and false negative results are possible. However, it doesn't mean that all the events (true positive assessment result, true negative assessment result, false-positive assessment result, false-negative assessment result) have to have equal probabilities, and the main feature of a good assessment is that the first two events have to be much more probable than the other two.

The goal of the work is to describe a way for an automatic generation method for multiple-choice assessments and multiple response assessment as well as their quality assurance allowing to generate assessments with a given discrimination ability, and an ability to range the testees who successfully passed the assessment according to their knowledge, skills and abilities level.

3 Basic Terms

The main aim of an assessment, either it is multiple choice or multiple response test, is to evaluate testees' knowledge, skills, and abilities according to Bloom's taxonomy. It includes six levels [5]:

1. remembering: retrieving, recognizing, and recalling relevant knowledge from long-term memory.
2. understanding: constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3. applying: carrying out or using a procedure for executing, or implementing.
4. analyzing: breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.
5. evaluating: making judgments based on criteria and standards through checking and critiquing.
6. creating: putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

It is obvious that an assessment hardly can be used at the highest levels of the taxonomy at least because it's hard to deal at these levels without formulating consistent oral or written answers, not mentioning creation or proposing some practical solutions.

A multiple-choice test is a form of an objective assessment in which respondents are asked to select the only correct answer out of the choices from a list [7] while a standard type of multiple-response or multiple-answer question looks like an MCQ except that the student can choose more than one answer.

A typical task includes a stem (the text that describes the task itself, may include diagrams, pictures, photos), options (the options for testee to choose from, may also include diagrams, pictures, photos) which consist of answers (the options to be marked as correct) and distractors (the options not to be marked). The options chosen by the testee are called the response.

The components of the task of an assessment are shown in Fig. 1.

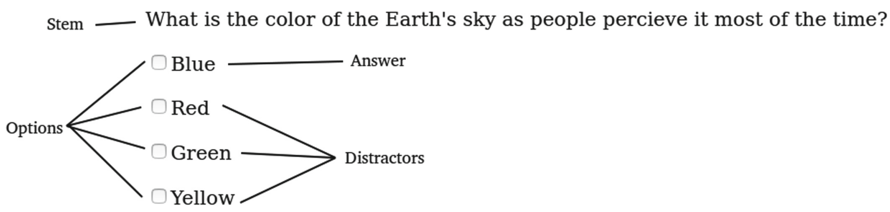

Fig. 1. Task structure

An assessment consists of a list of tasks. The number of the tasks in an assessment may vary, but typically an assessment consists of about 10–15 tasks.

4 Test Quality

As the goal of a test is to estimate the knowledge, abilities, and skills of a testee, a test must provide special features.

These features are:

1. validity
2. discrimination ability
3. reliability

Each feature supports assessment results in different ways.

The validity of an assessment means it estimates exactly what it is intended to estimate, or, in other words, validity is defined as the extent to which scores obtained on an assessment instrument represent true knowledge [12]. The validity of a test is defined by its content (the content of the stems and options of the tasks of the test) mostly and is set at the moment of the test tasks' development.

The discrimination index of a test shows how it differentiates the testees who have required knowledge, skills, and abilities from the ones who haven't.

The Classical Test Theory describes the reliability of a test in terms of observed score, true score, and random error component. It states that an examinee's observed score (X) can be decomposed into her/his true score (T) and a random error component (E) (X = T + E) ([3]). In fact, the less E value is, the more reliable assessment we use.

In some way, we can perceive the reliability of a test how its ability to maintain the same (or close enough) results for the same testee from an attempt to attempt. For example, if the testee passes the test a few times in a row, the results of the test would be the same (at least in terms of passing/not passing the test). In the reality the question of the reliability of a test is not that simple: the testee who passes a test few times in a row, learns from his or her own mistakes, so theoretically it is possible that the testee who had not enough knowledge before the test, would get it during the first attempts of passing the test.

The question of the reliability of a test is connected with the process of test development as we are going to see later in this article.

5 Test Result Calculation

There are a lot of ways to calculate the results of a multiple-choice assessment or multiple response assessment. In this article, we consider the approach the author uses for his own testing purposes.

The result of a test is calculated according to the following formula:

$$S = \frac{|A \cap M| + |D \cap N|}{|A \cup D|}$$

where S is the score of the assessment,

A - a set of a tests' answers,
C - a set of the tests' options, marked by a testee,
D - a set of a tests' distractors,
N - a set of tests' options, not marked by a testee.

In some way, this metric corresponds to the Jaccard index [10], also known as Intersection over Union or the Jaccard similarity coefficient.

The formula here is modified a bit according to the fact that the answers set and the distractors set have no common elements.

Using the formula allows us to avoid the situation of cheating by marking all the possible options of a test (maximizing the number of positive answers), or not marking options at all (minimizing the number of mistakes).

This formula is applicable both for multiple-choice assessments and for multiple response assessments.

6 Test Reliability

6.1 Passing Threshold Calculation According to the Stochastic Nature of Test Passing

The main question of an assessment is how to decide whether the test is passed or not, according to the testee's score, calculated using the formula provided earlier.

In most cases the author of a test sets the passing threshold, different authors set passing thresholds different ways. Typically the required percent to pass a test is set to 60–75%.

It is obvious that the passing of a test is a stochastic procedure. A testee may pass a test having no knowledge, skills, and abilities at all, though the probability of that event is reasonably low.

We need to establish a procedure to calculate a test passing threshold that guarantees that a test cannot be passed without having knowledge, skills, and abilities with the given probability. In other words, the threshold value has to be chosen the way that in 95% (for example) attempts a testee without knowledge, skill, and abilities fail the test.

The intention to make an assessment as cheating-proof as possible often gets tests authors to provide different tests for the different testees (generated from a common task pool), which makes it even harder to set the passing threshold.

To establish the correct passing threshold for a given test, we need to know the probability of each test outcome. To get the probabilities we can perform test passing simulation. It gives us the following pictures.

Here the distributions for different answers and distractors numbers in an assessment are presented.

The X-axis shows a test outcome calculated using the formula we discussed earlier, and the Y-axis shows the probability of the given test outcome. A is the number of answers in a task, and D is the number of distractors. All the tasks in an assessment have the same number of answers and distractors. The first column of the diagram corresponds to multiple-choice assessments, the second one corresponds to multiple-response assessments. The simulations for each answer/distractors ratios were performed for 100000 times.

As you can see, the greater numbers of answers are more preferable as they produce more possible test outcomes. Also, the probability to occasionally get higher outcomes is lower than for a lesser number of answers in tasks.

To set the passing threshold we can use the following method:

1. set the probability of occasional test passing (5% for instance)
2. starting from the highest outcomes sum the probabilities of the outcomes
3. stop when the sum is equal or higher than the required test passing probability we set
4. the outcome we found is the threshold we are looking for.

The vertical lines on the diagram above show the corresponding tests passing thresholds (Fig. 2).

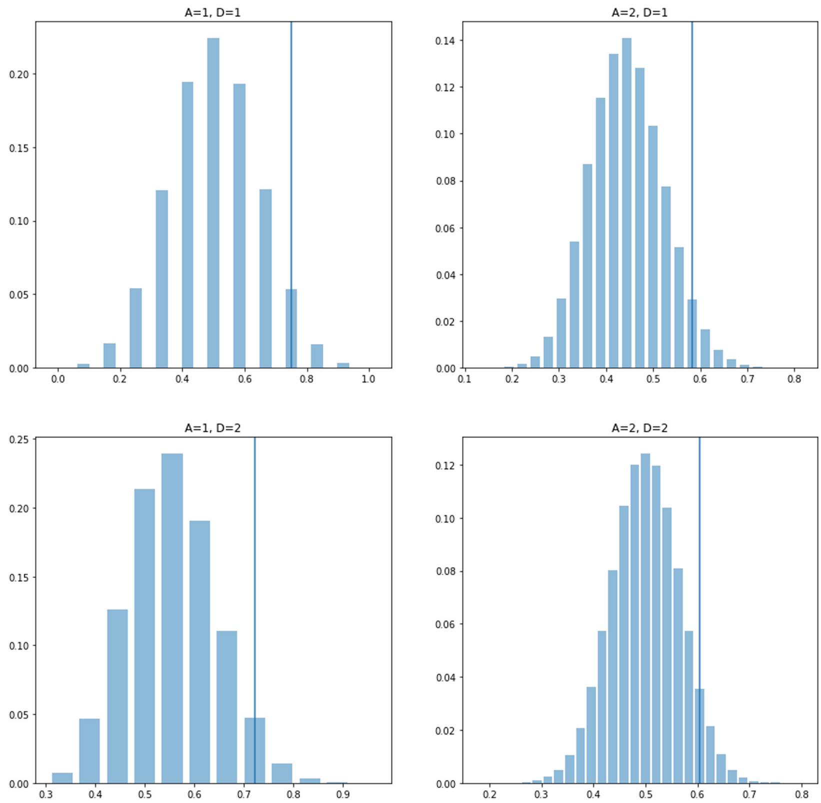

Fig. 2. Distributions for different answers and distractors numbers in an assessment

In real-life scenarios, the number of answers and distractors are seldom the same for all the tasks in a test (unless the authors of a test specifically intended to create the assessment that way). In most cases, the number of answers and distractors differs from task to task so we have to check that kind of scenario too.

It is obvious, that for a reliable test the higher outcome is, the harder it is to get it answering the test tasks by random.

Unfortunately, it is not correct for the tests where the number of answers and distractors differs for different tasks of the test.

Distributions for real tests are shown below (Figs. 3 and 4).

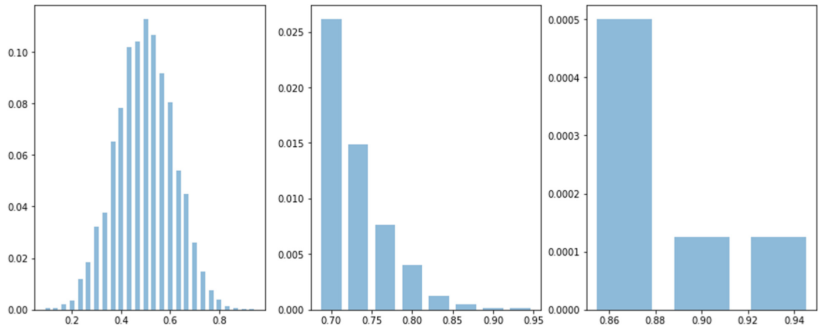

Fig. 3. Real test distribution

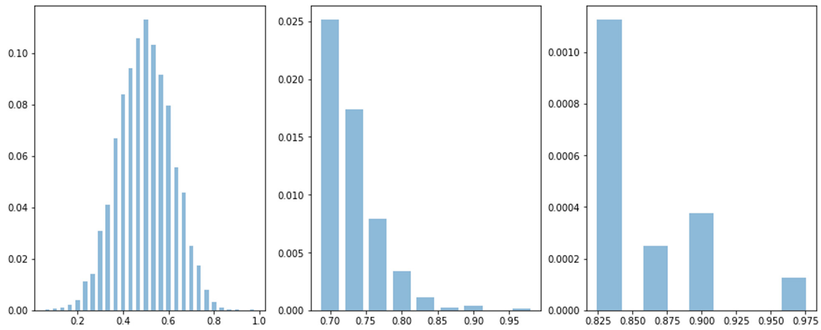

Fig. 4. Real test distribution

The first column demonstrates the whole distribution picture, the second one shows the part of the distribution that corresponds to the passing test outcomes, and the last one pictures the detailed part of the distribution where the rule described above is broken.

It is obvious, that the shown assessments are not reliable in the meaning we discussed earlier, as they provide a higher score with a higher possibility to achieve it comparing to the probability of the lower outcomes.

So we as an assessment developers have to establish the procedure to generate an assessment that is reliable, the way so the probability for a testee to get a high outcome is as lower as higher the outcome is.

Also, if we are to grade the testees, the number of assessment outcomes that correspond to a successful assessment passing has to be as high as possible.

So finally we propose a reliable assessment generation procedure.

6.2 A Reliable Test Generation Procedure

To achieve all we have mentioned above the following approach is proposed:

1. Set the probability of occasional test passing (5% for instance) P
2. A given number of tasks for the assessment are extracted from a task pool (what allows us to reduce the cheating probability during the assessment, generating a unique assessment for each testee);
3. Then for the assessment we generate, the procedure of random answering is preformed for the fixed number of times, simulating the assessment passing process. It allows us to discover the distribution of the outcomes of the test.
4. The threshold is defined as a percentage of correct answers, that provides the probability to pass the assessment that is less or equal to the given value of probability P:
    1. starting from the highest outcomes sum the probabilities of the outcomes.
    2. stop when the sum is equal or higher than the required test passing probability P.
    3. the outcome value we found is the threshold T we are looking for.
5. For each outcome that is higher than the threshold T check if the probability to get each next assessment outcome is lower than the current one is. If it is not so, the assessment has to be rejected.
6. Then the ranging ability of the assessment is evaluated as a number of possible assessment outcomes between the calculated threshold T value and the highest possible score. If the number is less than a predefined value, the assessment is also rejected.
7. If the assessment was rejected, the generation procedure starts again.

This procedure can be also used to evaluate the reliability of an assessment. For that step 2 should be excluded from the generation procedure, the other steps are the same.

An online assessment web application based on the proposed method has been developed in the form of a python web application.

It uses JSON files as data storage.

The time for each assessment is limited.

The assessment for each student is unique in terms of the uniqueness of the task set in an assessment. Some of the tasks can be presented in more than one assessment, but the whole combination of the tasks for each assessment is unique. The more tasks we have in the task pool, the fewer common tasks each particular assessment shares with the other ones.

For each assessment, its own passing threshold is calculated according to the procedure described above. The information about each attempt is stored as a JSON file, including the date and time of the assessment creation, the time when the assessment was started and finished, all stems, all options, a list of answers and distractors, the testee's response, the calculated passing threshold, and the distribution of the calculated outcomes.

The assessment process is shown below in the form of a sequence diagram (Fig. 5):

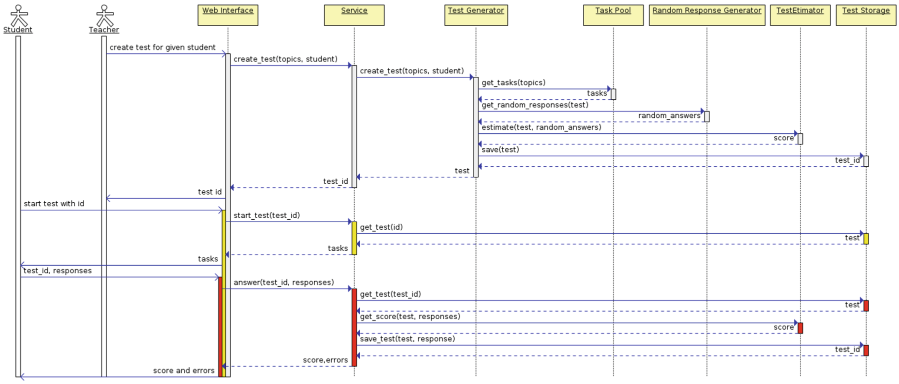

Fig. 5. Sequence diagram

The application has been used for three years for assessing students of Siberian State University of Science and Technologies. A comparison between the proposed methodology results and the classic exam shows the high efficiency of the proposed approach.

7 Actual Outcomes

The proposed approach is a convenient means allowing to assess knowledge, skills, and abilities of students. It provides an objective way to generate an assessment, allowing us to evaluate its discrimination ability and its testees' ranging ability. The discrimination and ranging abilities of assessments generated by the proposed procedure highly correlate with the ones for the traditional exams.

The on-the-fly generation of the assessment allows us to provide each testee with a unique assessment, preventing the assessment cheating by decreasing the possibility to discuss the tasks of the assessment the testee passes at the moment among the other testees or third parties.

The implementation of the system in the form of online assessment system also allows us to use the information about testee's answering process to prevent cheating using machine learning technologies.

To overcome the proposed approach it would require consolidated testees' efforts to collect and to answer all the tasks in the task pool. If the time window for the testing is limited, this possibility of cheating the system is also reduced.

8 Conclusions

The proposed approach can be easily integrated into an existing teaching process, especially if the online assessment systems are in use already. Using the described approach allows us to increase the objectiveness of an assessment process. The online assessment system can be used both for scheduled surveys and for pre-exam surveys, as well as students' exams self-preparing.

Surveys performed in the university show that the differentiation ability of the presented approach is at least at the same level comparing with more traditional approaches like colloquiums and interviews, providing the tasks of the assessment are built correctly.

As a drawback of the described approach, the complicated procedure of the assessment threshold calculation method can be mentioned. Sometimes it's hard to explain to testees how their results have been got. The threshold calculation procedure itself also takes a noticeable time as it requires the continuously repeating answering process simulation.

One should note that the multiple-choice assessment, as well as multiple response questions, are not a substitution for traditional exams or interviews, especially because of different abilities of students in the field of communication and social interaction.

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Career Strategies Approach for the Digitalised World Requirements

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Abstract. In the conditions of global digitalization of business, which influence on the competitiveness of entrepreneurs, on complete regions and national economies, it is of great importance to implement graduates career strategies. In the paper authors offer the approach of development a successful graduates career strategy, aimed in the systematic implementation of the formation of professional competences of young people.

In the research the questionnaire was conducted among students regarding their motivation for study and employment, and in-depth interviews based on open questions were used to identify the main factors influencing the career development of managers and specialists who are associated with digitalization. The social features of the development of graduates career strategies are revealed. One of the main social barriers to the implementation of career growth strategies is the social stereotypes that exist in society and guide young people in ineffective career scenarios.

The authors proposed an effective model for the development of the successful personal career strategy based on the development of professional digital competencies.

Keywords: Career strategy · Digitalization · Social factors · Skills · Education

1 Introduction

The rapid socio-economic transformation in modern society, a change in the human worldview is associated with significant uncertainty in anticipation of the future. The scientific and technological revolution has led to the emergence of new technologies that blur the boundaries between the physical, digital and biological spheres.

The works of K. Schwab and N. Davis substantiated the features of radical changes in technologies that will entail changes in the labor market, in the economy and education [1, 2]. These forecasts testify to the growing role of human capital, its intellectual form, on the one hand, and on the other hand determine the requirements for specific resources that are necessary for its successful accumulation and capitalization. Increased competition in world markets and significant differences in socio-economic development in different countries of the world require special attention to

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human capital and its intellectual assets. It is in these new circumstances that the intellectual assets of human capital become the main factor in competitiveness and leadership in the global economic space.

Intellectual assets is a specific component of human capital which the set of cognitive, creative, emotional competencies of the economically active population, providing value creation and progressive dynamics of profitability and value. All intellectual assets have an intangible form and competency content, that is, they are considered in the system of productive qualities of the carrier/owner. Their performance provides current and future benefits for the bearer/owner and all levels of the environment [3]. The development of human capital and its intellectual assets, as well as their effective use, are ensured in the process of forming the conscious priorities of the individual through a highly developed technological level of the educational process stimulating the continuous development of a person throughout life. The main factor affecting career strategies and the development of intellectual assets of human capital is the conscious choice and formation of an active life strategy, its implementation in a practical plane.

2 Purpose or Goal

The value approach determines the social characteristics of a career as a social phenomenon. It is important to determine the set of values of a person who plans or implements a career strategy, and it is important to differentiate this value according to established priorities. The components in its value set can lead to some value resonance, which should be taken into account when planning and implementing career growth strategies when developing professional competencies of youth.

The decisive changes caused by the consequences of the scientific and technological revolution require fundamental changes in the worldview of young people, the formation of a new vector of personality development aimed at developing career strategies and the formation of professional competence.

It is the quality and timeliness of determining the personal inclinations of youth and a more conscious approach to career development that affects the success of personal realization in modern society.

3 Findings to the Study of Human Capital and Career Strategies

The problems of the formation of human capital and its effective use have been the subject of discussion for many decades. Particularly increasing attention to this issue at a time when there is a massive intellectualization of most processes of human life.

The relationship between intellectual capital, innovation, and sustainable development was investigated by F. Matos, V. Vairinhos, S. Durst, and R. P. Dameri [4]. A. Bounfour and L. Edvinsson [5] point to the significant value of the modern development environment, which is closely related to knowledge and intellectual capital and determines the productivity and competitiveness of the business and the public sector. The policy of creating a “smart city” and developing an appropriate “smart” strategy is justified by R. P. Dameri, F. Ricciardi and B. D’Auria as the only basis for the development of intellectual capital [6, 7]. P. Mclaughlin, B. Kennedy, A. Galluzzo and M. Donato reveal the importance of new fast-growing STEM skills related to adaptive thinking, coding and technology knowledge, project thinking, integrated problem solving and analytical thinking [8]. It is the quality and timing of determining one’s inclinations and a more conscious approach to career development that affects the success of the realization of the potential of the individual.

For the formation of socio-emotional competence of the individual, which is a necessary critical factor for targeted actions in the future, preventive impacts in the learning process are necessary [9]. Important is the study conducted by A. Godwin, G. Potvin, Z. Khazari and R. Lok, which proves that a person’s career choice is confirmed by gender characteristics and his ability to develop over a certain period [10]. Conclusions E. Ruzek, C. Hafen, J. Allen, A. Gregory, A. Mikami and R. Pianta, make it clear that emotional support from the teacher contributes to the development of a greater ability to be independent in matters of everyday life and have a more positive relationship with peers [11]. That is, behind the conclusions of White R.W., motivation promotes the learning process, effective interaction with the environment and the development of relevant competencies [12]. The conclusions of E. Deci, A. Olafsen and R. Ryan are important, which reveal the characteristics of internal motivation of an individual and externally controlled motivation and influence the choice of priorities for career development [13].

C. Christensen noted the significant success not only of companies, but also of individuals in the development and implementation of development strategies [14, 15]. Subsequently, C. Christensen, along with J. Allworth and K. Dillon, proposed a series of guides on finding the meaning of life and happiness. C. Christensen points out the importance of using knowledge and time in training for developing a life strategy [16]. Christensen C. also substantiates the leading role of universities in personality development, the development of its key skills and intellectual capital as a whole based on innovative changes [17]. When planning a career as a person, as R. Sutien points out, it is important not to go out of fashion, but to find a field of activity, a profession in which a person can be better or better than others [18, 19]. In accordance with this, an important role in this area should be given to professional competence and personal career strategies – the ability to generalize and implement them and find a field of activity, a profession in which a person can be better or better than others. Career strategies due to the systematic process of coordinated actions have a high probability of optimal investment of time and money.

The effectiveness of the choice and implementation of a career strategy (or a group of them) is determined by the quality orientation of young people and the conscious determination to form appropriate professional competencies. Career success, which is described by two indicators: the goal - the manifestation, which is wages and career advancement, and the subjective - career satisfaction is provided mainly by professional competencies, although soft skills are important. Of particular note are the following 6 career competencies that affect the integral assessment of career success [20]: the ability to update your career; career reflection; ability to relate to career aspirations and values; study of work; career planning and the ability to evaluate the impact of training and work processes on its course; the ability to build the necessary contacts and connections for career development. Thus, the formation of a career should take into account the individual characteristics of the actors involved in the process, and the corresponding promotion strategies, as well as a system of measures for building your own and unique career history, focused on the personal needs of the system.

Increasing the rate of intensification of socio-economic interaction is changing the very essence of career strategies. This process directly depends on the reproduction of labor, as it forms certain career archetypes. They form the image of a successful career strategy, which is taken as a template when planning its personal form [21]. In particular, today the nature of the reproduction of labor has changed, it is required mature personality with a high intellect, modern culture and a high level of commitment to effective work. That is, new career strategies for Ukrainians should be based or adjusted taking these factors into account. In the end, a person's career strategy is part of his image and, therefore, can influence the planning of youth career development strategies that are adequate to the current conditions of social development. To prevent social imbalance, it is necessary to develop certain sociocultural codes and, more specifically, update a specific type of culture, which should include sociocultural reflections on career strategies. In our opinion, this type of culture may be a technological culture, which we propose to consider as a special type of culture that combines social technologies for the development of social interaction in certain areas of sociocultural life.

4 Approach

A survey was conducted of students of Ukrainian universities with digital knowledge skills (n = 440) and the types of motivation to study and find a job were identified (Fig. 1). The first group (about 15%) includes the "best graduates" who have developed business and personal qualities and, as a rule, by the time they graduate, already have a small private business or have several current offers from different employers. They are a kind of benchmark for the rest of the student population. The second group (about 40%) are "careerists," who are oriented toward success in their professional activities, have their own work experience and positive employment practices. The third group (approximately 30%) is students who are not able to develop their careers, the so-called "disadaptants". As a rule, they are not ready to make efforts to find work and are independent in making their own decisions, employment in general. The fourth group (approximately 15%) was formed by unmotivated student youth with vague plans for professional growth.

Thus, almost half of the graduates have some conflict between the desire to work in their specialty and the degree of readiness to fulfill this desire. Many students want to get a job by profession, but because of their own passivity, they do nothing for this. The possible reasons are that they do not plan to work in their chosen field of study at all, passively waiting for employers to "pay attention to them". At the same time, more than half of graduates have clear career growth strategies, with young specialists focused not only on the size of their wages, but also on the possibility of further career growth in the labor market.

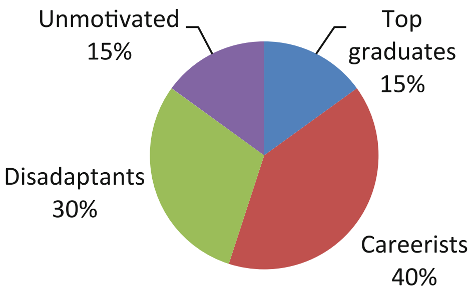

Fig. 1. Groups of students according to the carrer strategy

Interviews of managers and specialists who are associated with the implementation of digital skills confirms the presence of these 4 groups among potential candidates for employment. At the same time, a group of factors is justified, among which one of the most important is the presence of career strategies among young people regarding the acquisition and effective use of digital skills in the work process.

The authors modeled career strategies for students who take into account the level of their personal activity:

– an individual-career strategic behavior model, which is characterized by the desire to achieve personal success in life. Graduates who choose this model of career strategy, as a rule, simultaneously study and work. They focus only on themselves and try to achieve everything on their own. Many young people are interested in such active and proactive youth;
– an indefinite strategic model of behavior, characteristic of young people who have not decided on their own professional life and did not realize what exactly they want, sometimes not completely adequately assessing their capabilities. Employers usually lose interest in those candidates who unreasonably overestimate their requirements for the required job or are ready to consider offers for various positions in various fields of activity;
– a non-independent strategic model of behavior typical of graduates, in most cases very capable and prepared, but not guided by the requirements of the modern labor market, not possessing job search technologies.

Educational institutions should influence the ratio of active and passive career of student youth. Universities should create a highly effective corporate culture that will encourage students to learn and form their own career strategies. It is important to use six main motives: play, goals, potential realization, emotional impact, economic impact and inertia [22].

The pattern of forming a strategy for a successful personal career based on the development of professional competencies is proposed (Fig. 2).

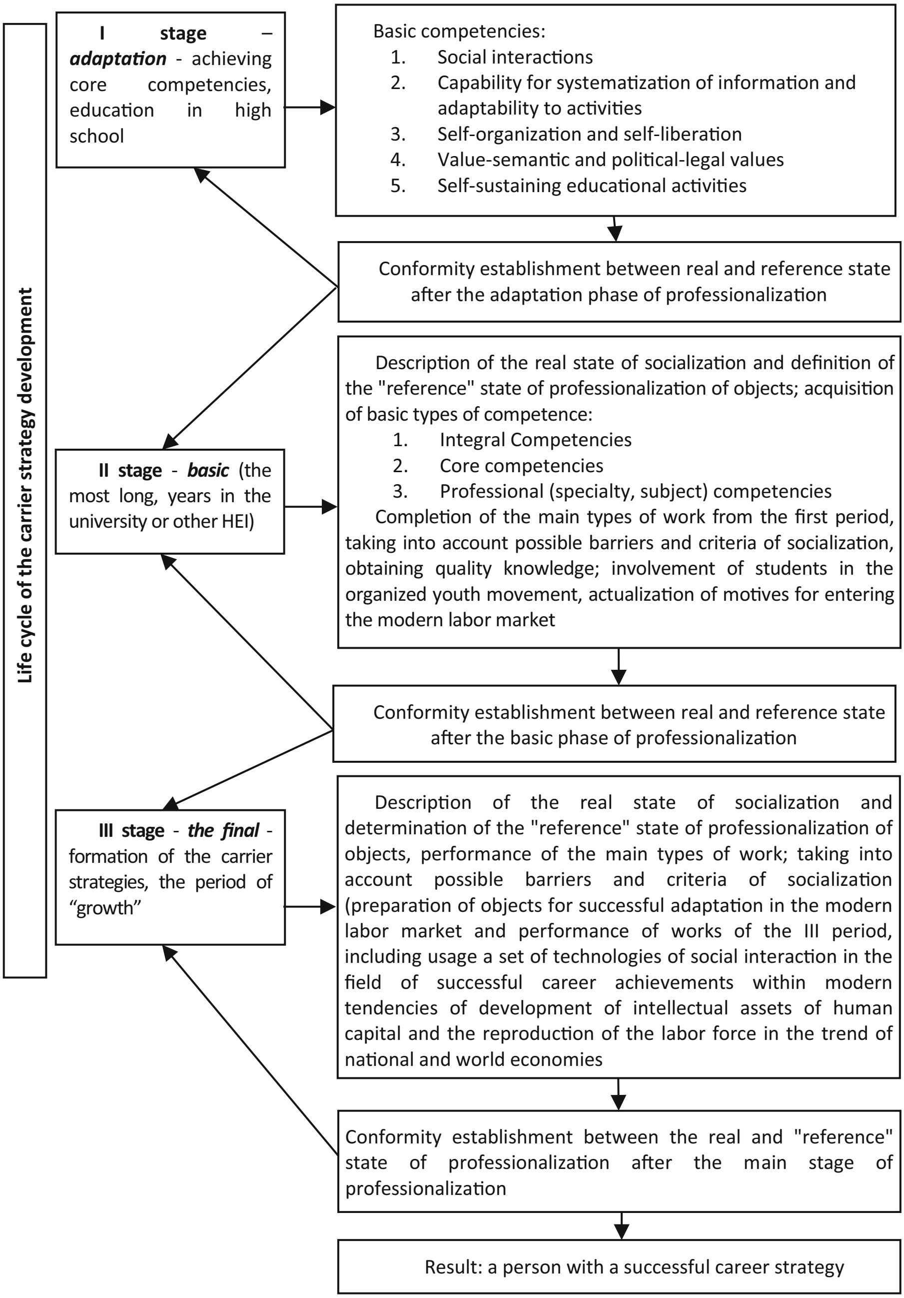

Fig. 2. The model of a successful career strategy development of a person

Despite the elements of social transformation that exist in modern Ukrainian society, it should be noted that today society is undergoing several global transformation processes. All these social transformations significantly change the conditions for the implementation of career strategies of members of modern Ukrainian society, but for better orientation in the new conditions for the implementation of career strategies, society requires specialized institutions – universities. The education system and, in particular, higher education should be the key to ensuring the implementation of career strategies. Education and higher education should be of high quality and meet the basic requirements of the labor market and economic development for this. Educational technologies should develop competencies, knowledge and skills that will help students find effective algorithms to implement their own career strategies.

5 Conclusions

In the process of global digitalization, there are taking place global changes in the reproduction of the workforce and new social conditions are developing for the implementation of personal career strategies. The authors have disclosed the social features of the development of personal career strategies are. One of the main social barriers to the implementation of career growth strategies is the social stereotypes that exist in society and guide young people into ineffective career scenarios.

The most powerful factor influencing the strengthening of youth career strategies is education. Educational technologies today should primarily develop digital skills, knowledge and skills that will help young people find effective scenarios for implementing their own career strategies. Universities must create a highly effective corporate culture that will encourage students to learn and shape their own career strategies.

The authors proposed effective technologies for the formation of successful personal career strategies based on the development of professional digital competencies.

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Poster: Engineering Education: Outcomes Assessment

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Abstract. The last ten years have observed the significant changes in the structure of Russian system of higher education. Nowadays, there are three levels of university education: Bachelor's, Master's and PhD programs. The system of higher education in Russia has been developing according to new educational standards. One of the main parameters of the standards are competences of graduates which are to meet the requirements of professional standards. To provide a high level of educational programs it is necessary to create a system of outcomes assessment which is based on international standards and requirements. The article presents the principles of outcomes assessment system for all levels of university education. The authors propose the descriptors of outcomes assessment of Foreign Language Course for Bachelor's, Master's and PhD students majoring in chemical engineering at the Technological university. Each descriptor is characterized by the actions of students and is a component for the whole scale of students' marks.

Keywords: Engineering education · University · Outcomes assessment

1 Introduction

"Grading is one of the fundamental facets of learning" [1]. Thus, in past decades it was just a grade given to a student. As the changes have taken place, the outcomes assessment has turned into one of the core elements in the process of higher education. Since the universities in Russia use new modern forms and technologies and implement the rating system, course grades help professors "in understanding student's ability, skills, and knowledge" [2]. Assessment is a tool to motivate students; it makes them realize that they are to work all term long, to master their skills and abilities; to use even imagination and creativity to succeed and achieve the goals during the course. However, students should know the descriptors and criteria they are to follow to do the course. So, in this paper we are going to present you the descriptors and criteria of outcomes assessment used at Kazan National Research Technological University.

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2 Approach

Outcomes assessment is a collaborative process of inquiry regarding student learning outcomes, followed by analysis, reflection, and action. The goal of outcomes assessment is to improve student learning and improve instructional programs. Outcomes assessment is not individual student, faculty, course, or program evaluation. Student learning outcomes are statements of what students know or can do upon successful completion of a course or a program. Student learning outcomes should provide the direction for all instructional activities. These outcomes can be assessed at different levels: they are statements of what students know or can do upon successful completion of a course or a program. Program-level assessment is used to determine how well the program as a whole prepares students to achieve the learning outcomes [3]. While program goals guide the development of the program, student learning outcomes are the hub of the outcomes assessment process. Clear and explicit learning outcomes strengthen the teaching and learning process by making the learning target visible for all to see. As Stiggins [4] points out, it's difficult for students to hit the target if they don't know what it is! As well, if teachers keep student learning goals front and center as they plan and teach, they are more likely to help students develop the essential knowledge and skills considered necessary for performance in the discipline or field [5].

New assessments must advance competencies that are matched to the era in which we live [6]. Contemporary students must be able to evaluate the validity and relevance of disparate pieces of information and draw conclusions from them. They need to use what they know to make conjectures and seek evidence to test them, come up with new ideas, and contribute productively to their networks, whether on the job or in their communities. As the world grows increasingly complex and interconnected, people need to be able to recognize patterns, make comparisons, resolve contradictions, and understand causes and effects. They need to learn to be comfortable with ambiguity and recognize that perspective shapes information and the meanings we draw from it. At the most general level, the emphasis in our educational systems needs to be on helping individuals make sense out of the world and how to operate effectively within it. Finally, it is also important that assessments do more than document what students are capable of and what they know. To be as useful as possible, assessments should provide clues as to why students think the way they do and how they are learning as well as the reasons for misunderstandings [7, 8].

The principles and tools of the outcomes assessment system were developed in Kazan National Research Technological University on the basis of European and American approaches. The system of outcomes includes descriptors which were created according to the competences and teaching tasks [9].

3 Actual or Anticipated Outcomes

Outcomes assessment was developed and applied for Bachelor's, Master's and PhD students majoring in chemical engineering. The system allowed us to create a logical connection between undergraduate, graduate and postgraduate studies for Foreign Language course. This in turn led to a reformatting of the entire student learning process. The result of the study varies according to the program [10].

Bachelor students have the following outcomes assessment system: first of all, they take a test on basic language skills (reading, writing, and speaking). These results give an English language educator the whole information about the students' knowledge and their foreign language level, according to which a professor "can customize instructional content and strategies to a particular group of students" [5]. Having chosen the strategies and the content of the course, a teacher gives student the comprehension of the assessment forms. In the classroom there can be week-to-week or month-to month observation as the form of motivation. Also, we can speak about different classroom activities and projects, quizzes, written papers, homework, communication tasks (individual or group work). These situations are referred to as assessments to assist learning, or the formative use of assessment. These assessments provide specific information about students' strengths and difficulties with learning. For example, foreign language teachers need to know more than the fact that a student does not understand some grammar rules, mispronounce words, has some problems with listening or speaking tasks; they need to know the details of this misunderstanding. Teachers can use information from these types of assessment to adapt their instruction to meet students' needs, which may be difficult to anticipate and are likely to vary from one student to another. Students can use this information to determine which skills and knowledge they need to study further and what adjustments in their thinking they need to make [8].

Table 1 presents the Bachelor's degree students' assessment scale.

Table 1. Bachelor's degree students' assessment scale

Reading				
Bad	Satisfactory	Good	Very good	Excellent
Makes a lot of mistakes, mispronounce the words, reads very slowly. Needs a dictionary, cannot answer the questions	Knows some of the reading rules, there are many mistakes in reading. Translate with the dictionary, can answer the questions	Knows how to pronounce the words, follows the reading rules, makes a few mistakes, uses dictionary, can retell it	Has 1–2 mistakes in reading, translates without a dictionary, can give summary	No mistakes in reading, translates the test without a dictionary, understands the reading passage, can analyze it and make conclusion
Writing				
A lot of spelling and grammar mistakes; the text is illogical and incoherent, no linking words, no structure, the language is poor	Has grammar and spelling mistakes, tries to use complex sentences and linking words. Doesn't follow the writing rules	Has some mistakes in grammar and spelling, uses a few linking words, the idea is clear and the passage has the correct structure	Makes 1–2 mistakes in grammar or spelling, follows the writing rules, uses linking words, but the passage meets the requirements	Writes without mistakes in grammar and spelling; the text is logical, choses proper terminology and linking words, uses synonyms and follows the writing rules

(*continued*)

Table 1. (*continued*)

Reading				
Bad	Satisfactory	Good	Very good	Excellent
Speaking				
The student doesn't know how to make a speech	Uses simple sentences, word order is incorrect, the speech is not spontaneous, clear and logical. Many mistakes in spelling and grammar	Needs some time to start speaking, has a little difficulty with word choice, sometimes makes mistakes	The speech is spontaneous, seldom can be mistakes in grammar or pronunciation, and knows how to use speech patterns and intonation patterns	The speech is fluent, clear, logical, and coherent. Uses correct intonation and speech patterns, linking words, complex sentences. The student can make spontaneous speech
Listening				
The student doesn't understand a foreign speech at all	There are a lot of unfamiliar words for the student, but still he can get the general idea of the text	The student understands the main idea, but finds it difficult to give answers to some questions (e.g. details or specific information)	Understand a foreign text or speech quite well, though there can be some unknown words; can answer the questions on the context	Understand a foreign text or speech, can guess the meaning of unknown words from the context. Can answer the questions, draw conclusion about the text

As it has been mentioned earlier, Kazan National Research Technological University provides logical connection between undergraduate, graduate and post-graduate studies for Foreign Language course, so it means that students continue learning the language mastering their skills and acquire knowledge about the subject-matter [11].

As a result, the educators worked out and use the descriptors for Master's degree students (Table 2).

So, as we can see the task for a Master's degree student can be creating a personal profile for a conference, making a CV, preparing a presentation on the research paper or writing an abstract for a foreign journal. This requires not only excellent skills in reading, writing and speaking, but also the abilities to analyze, summarize, conclude, make a report, and give a speech in public.

Table 2. Master's degree students' assessment scale

Indicators (general results)	Descriptors (the result of education in certain actions)				
	1	2	3	4	5
Oral communication	Finds and sorts out the data	Writes the text for the report in a foreign language	Makes the presentation based on the report	Gives the speech in a foreign language, answers the questions on the research	Has reasonable opinion about own or groupmates' works
Written form of communication	Sort out the data to write an abstract on the research	Prepares the text of the abstract of the research in a national language	Writes the abstract on the research in a foreign language	Writes the abstract on the research in a foreign language considering the submission	Polishes up the abstract considering the submission
On-line communication	Knows the site of the journal or the conference to log in	Follows the procedure to log in	Successfully completes the registration form	Uses the account to make some changes (e.g. personal information)	Compares various form of fulfilling the registration forms and defines more convenient ones

4 Conclusions

In the age of globalization educators should not only assess foreign language grammar, reading or translation but also the ability to implement the obtained skills both in everyday, professional and academic communication. Too much emphasis on assessment leads to "teaching to the test" and an emphasis on getting the "right" answer. Too little emphasis on assessment leads to no intentional directions and a meandering of learning [12].

Moreover, it be should mentioned that students are to care not only for the grades or marks given by the professors, teacher or educators. The core component is knowledge and skills. The process of education is a close and constant collaboration between students and professors, and only in this case we can obtain good results and achievements [13, 14]. On the one hand, much depends on students themselves and the desire to acquire information, but on the other hand, a teacher should provoke the willingness to advancement and study. At the technological university educators use this assessment scale for Bachelor, Master's and PhD degree programs to develop and control practical skills of a foreign language starting from conversational English to English for special and academic purposes.

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Internet of Things and Online Laboratories

Learning Methods Based on Artificial Intelligence in Educating Engineers for the New Jobs of the 5th Industrial Revolution

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Abstract. A study conducted by the World Economic Forum revealed that about 75 million jobs will disappear because of the Artificial Intelligence (AI), but AI will bring with it more than 133 million new job. Therefore, for making a smooth transition to the next Industrial Revolution, the reskilling initiatives play a key role. In the information age, it is crucial to educate students to acquire the skills necessary for the new jobs that will be created thanks to AI. Because everything we touch and everything we do will be enhanced by AI in the near future, new ways of working will become increasingly popular. Therefore, this paper aims to define new learning methods based on AI to educate engineers for the jobs that will emerge in the following years.

AI is the fusion of many fields of study. Electrical engineering and computer science are determining the hardware and software implementation of the systems based on AI. The teaching practice used in this study combines several fields of study and is based on using LabVIEW including the Deep Learning Toolkit (DeepLTK) and Python Node to teach engineers all the necessary steps for developing, validating and deploying machine learning-based systems.

The approach is based on learning by examples and by comparisons with human intelligence, methodologies which have proven to be very efficient. The key anticipated outcome of this study is that students and engineers will gain relevant knowledge about the powerful machine learning algorithms.

Keywords: Artificial Intelligence (AI) · Deep Learning · 5th Industrial Revolution · LabVIEW · Python

1 Introduction

Because of the rapid technological progress, Artificial Intelligence (AI) has become much more popular. Algorithms, developed by human programmers, are trained on massive data sets and produce very accurate results that shocked even the pioneers of this field. Even if now it is not very common, general AI will soon begin to take away

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many common jobs from people - such as drivers, economists, radiologists and engineers. According to a study conducted by the World Economic Forum, it is supposed that about 75 million jobs will disappear because of AI, but AI will bring with it more than 133 million new job.[1]

A key part of making a smooth transition to the next Industrial Revolution are the reskilling initiatives. Artificial Intelligence turned out to be very efficient for jobs that are either rules-based or repetitive. Consequently, many economists are concerned that, in developing countries, low-wage jobs will be quickly lost. There are still some ways that a developing country, with relatively high unemployment rate, can gain certain benefits from the AI development: for example, engineers can pre-process, analyze and clean the dataset for a deep neural network. This kind of work doesn't require expensive infrastructure or extensive knowledge about AI algorithms, but it can be used by some of the most complex AI systems that are available today. Therefore, this paper aims to define and describe learning methods based on AI to educate engineers for the jobs that will emerge in the coming years.

AI is the fusion of many fields of study, as electrical engineering and computer science are determining the hardware and software implementation of the systems, while statistics and mathematics determine how the performance and accuracy of the models can be measured [1]. The teaching practice used in this study combines these fields of study and is based on using Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW) including the Deep Learning Toolkit (DeepLTK), developed by Ngene, and Python Node, to teach engineers all the important steps needed to develop, validate and deploy deep learning-based systems using the LabVIEW programming environment.

The methodology involves educating students to develop a machine learning system from scratch using LabVIEW, starting with the exploratory data analysis and cleaning step. Then they will learn by example which criteria to consider in order to effectively split the data into training, validation and test sets and to fit and evaluate the initial model. The next steps include the hyperparameter tuning, the validation set evaluation and selecting the best model, depending on their accuracy and precision.

To develop AI systems responsibly, ethical issues which can occur must be considered as well. This approach is based on learning by comparisons with the human intelligence and by examples, methodologies which turned to be one of the most efficient ways to learn machine learning. The key anticipated outcome of this study is that students and engineers will learn which powerful machine learning algorithm to choose for their specific problem, by being aware of the advantages and disadvantages of the most used supervised learning algorithms, like linear regression, logistic regression, k-nearest neighbor (KNN), neural networks, random forest and support vector machines (SVM). They will also be familiar with the most performant neural networks, like multilayer perceptron, convolutional neural network (CNN) or recurrent neural network (RNN).

[1] World Economic Forum website, [Online] at https://www.weforum.org/projects/reskilling-revolution-platform, last accessed: 20.05.2020.

2 Exploratory Data Analysis and Data Cleaning

2.1 Exploratory Data Analysis

As the first step, the engineers should learn how to perform an exploratory data analysis, for summarizing the main characteristics of the data through graphics and visual charts. It also helps to understand the shape of the data set, to learn which features might be useful and to inform the cleaning that will come next. Exploring the training data sets is crucial for developing an accurate machine learning model.

This step involved getting counts and distribution of all variables, looking at each feature of the data and understanding the correlation between the features. Duplicates should be found and eliminated from the data sets, while missing data must be checked as well [2].

One useful thing to understand is which features can be strong indicators for making an accurate prediction. In order to see the shape of the features and how they relate to the target variable, we plotted overlaid histograms where we can compare the distribution of a certain variable.

For doing exploratory data analysis, the Pandas library from Python is certainly the best choice. The data acquisition was done in LabVIEW using a Data Acquisition Device (DAQ) from National Instruments, and then export the collected data to a text file or CSV file [3]. The file can be easily imported in Python and analyzed with just few standard lines of code, which can be done even by people without programming knowledge (Fig. 1).

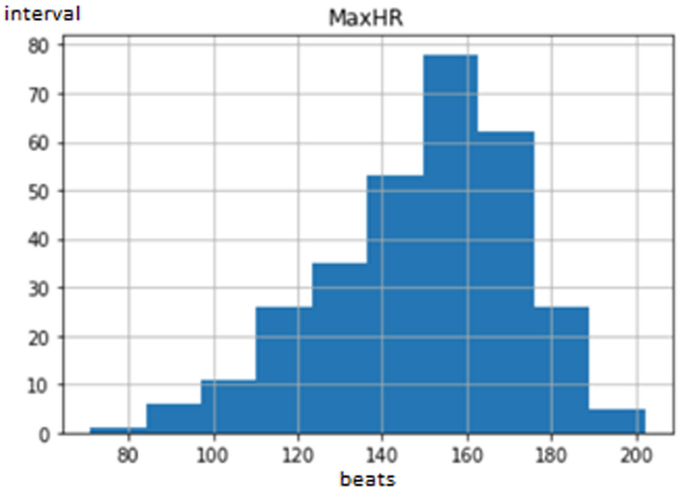

Fig. 1. Exploratory data analysis histogram for MaxHR feature

2.2 Data Cleaning

After finishing the exploratory data analysis, the dataset requires often a significant amount of cleaning or pre-processing, before it can be analyzed or used for building the machine learning model. The main purpose of this step is to teach the engineering students how to shape the data such way that a model can best pick up on a signal and to remove irrelevant data in order to adjust the features to be acceptable for a model.

There are several ways and domain-specific techniques for performing the data cleaning, depending on the type and shape of the data we are using. If we are analyzing signals, then we should remove noise from our data using advanced signal processing algorithms and then merge the data with different sample rates. Other important thing to do is selecting only the significant features for reducing the amount of data we will use to fit the model. If there are missing values for a feature, they should usually be replaced with the mean value for that feature, while repetitive and not really useful variables are to be taken out of the model [4]. Regardless of the type of the data, it also necessary to clean up the duplicates, outliers and errors from our dataset.

This step was handled in LabVIEW using the graphical programming language G, which didn't require to write any line of code. Using LabVIEW, cleaning the acquired signals by removing the unnecessary noise or applying filters is a very straightforward process [3] (Fig. 2).

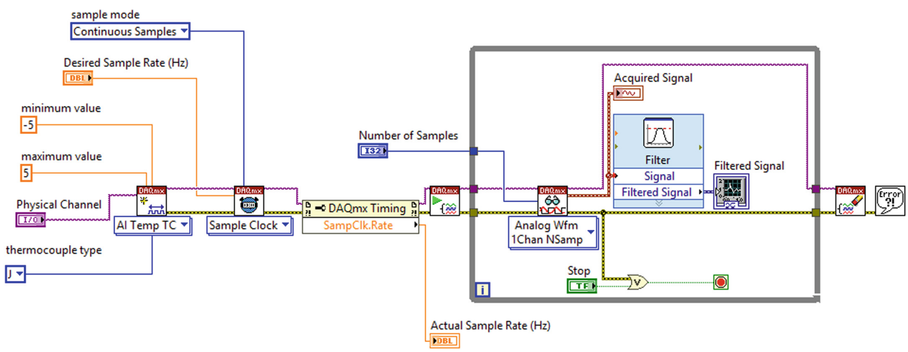

Fig. 2. LabVIEW block diagram for applying filters to an acquired signal

3 Splitting the Data into Training/Validation/Test

A common task in machine learning is to develop algorithms that can learn from the data and then make predictions on unseen data. These algorithms are making decisions or predictions by using a mathematical model built from the input data.

The data used for building the model can come from multiple datasets. There are three main sets used in different stages of building a machine learning model: the training dataset, the validation dataset and the test dataset [5]. Therefore, the engineers should be able to split the collected data accordingly.

The size of each of these three datasets should be chosen by the developer and may vary depending on the specifics of the problem, but as a general approach it is advised that the training set should comprise more than half of the available labeled data, usually around 60%. The validation and training subsets should each contain around 20% of the initial set.

The machine learning system uses the training data to train the model for finding patterns in it. The validation set is used to select the best model, specifically the optimal algorithm and the best hyperparameter values, while the test data is used then to evaluate how the model will look in a real environment. The system evaluates the predictive performance by comparing the actual output with the expected output and we considered three evaluation metrics: accuracy, precision and recall. The formula for calculating each metric is shown in the Table 1 below.

Table 1. Evaluation metrics of a machine learning system

Evaluation metric	Formula
Accuracy	$\frac{\mathit{Number\ of\ correct\ predictions}}{\mathit{Total\ number\ of\ predictions}}$
Precision	$\frac{\mathit{Number\ of\ correct\ positive\ predictions}}{\mathit{Total\ number\ of\ positive\ predictions}}$
Recall	$\frac{\mathit{Number\ of\ correct\ positive\ predictions}}{\mathit{Total\ number\ of\ positives}}$

There are some risks associated with not splitting the full dataset: the model can overfit or underfit the data, which could lead to a situation when the model will not be able to generalize accurately.

A holdout test set is any data set that was set aside and not used in fitting a model. It helps to evaluate the machine learning model's ability to generalize on unseen data. Both the validation and test sets qualify as holdout test sets. Another useful algorithm for building performant machine learning models is K-fold cross-validation – it is a process in which data is divided into k subsets and then the holdout technique is repeated same number of times. In each step of this process, one of the subsets is used as a test set, while the other subsets are combined and used together as train data.

Both the data splitting and K-fold cross validation can be can be best done in Python, and then the Python code can be imported easily imported and run in LabVIEW using the Python Node module, available in LabVIEW since the 2018 version. Because the *train_test_split* function from Sklearn allows only two parameters, the split into three categories was done in two steps. For this whole process, there are only few lines on code needed with some configuration parameters, as illustrated below:

```
X_train_set, X_test_set, y_train_set, y_test_set =
train_test_split(features, labels, test_size=0.4,
random_state=42)

X_test_xet, X_validation_set, y_test_set,
y_validation_set = train_test_split(X_test_set,
y_test__set, test_size=0.5, random_state=42)
```

4 Fitting an Initial Model

The purpose of this chapter is to teach the engineers how to choose the appropriate supervised learning algorithm for their problem, by comparing the most widely used algorithms: linear regression, logistic regression, k-nearest neighbor (KNN), random forest, support vector machines (SVM) and neural networks [6]. In this comparison we considered the following indicators: the type of the problem they can be applied to, the average predictive accuracy, the training speed and the prediction speed.

Table 2. Comparison of supervised learning algorithms

Algorithm	Problem type	Average accuracy	Training speed	Predictive speed
Linear regression	Regression	Lower	Fast	Fast
Logistic regression	Classification	Lower	Fast	Fast
Support vector machines	Classification	Medium	Slow	Moderate
KNN	Both	Lower	Fast	Depends on the parameter n
Random forest	Both	Higher	Slow	Moderate
Neural networks	Either	Higher	Slow	Fast

As we can see in Table 2, some algorithms have a lower accuracy but a fast training and predictive speed, while other have a slow training speed, but a high average accuracy. The training speed is not a really important criterion, because the training step is done only once, but the accuracy and the predictive speed are both very important. Therefore, the artificial neural networks are the most powerful techniques and we focused our education process on neural networks.

There are three main deep learning types of artificial neural networks: the multilayer perceptron (MLP), the convolutional neural networks (CNN) and the recurrent neural networks (RNN). These types of neural networks are now the core of the machine learning revolution, used in many different applications like self-driving vehicles, natural language processing, signal processing, etc. [7]. The choice of the right neural network type is dependent on the type of the data we have (Table 3). While a multilayer perceptron fit best on tabular or numerical data, recurrent neural networks are widely used for sequence data, like audio, time series or biomedical signals and convolutional neural networks on images [8].

Table 3. Main types of artificial neural networks

	MLP	RNN	CNN
Data	Numerical data	Sequence data	Image data
Recurrent connection	No	Yes	No
Parameter sharing	No	Yes	Yes
Spatial relationship	Yes	No	Yes
Vanishing & exploring gradient	No	Yes	Yes

5 Building the Model

After choosing the right model for the given problem, engineers should be educated how to build an accurate machine learning model. There are many Deep Learning powerful frameworks (TensorFlow, Torch, Carafe), but most of them are only supporting the C, Python or Java programming languages.

We used the Deep Learning toolkit (DeepLTK) from Ngene, which is a high-level API completely developed in LabVIEW and doesn't require any external library to work. It can run on either CPU or GPU and provides capabilities to build, train, test and deploy deep neural networks in the LabVIEW environment.

To build a neural network in LabVIEW we used the NN_create.vi virtual instrument from the DeepLTK module, that creates and sets up a context for a new neural network [9] (Fig. 3).

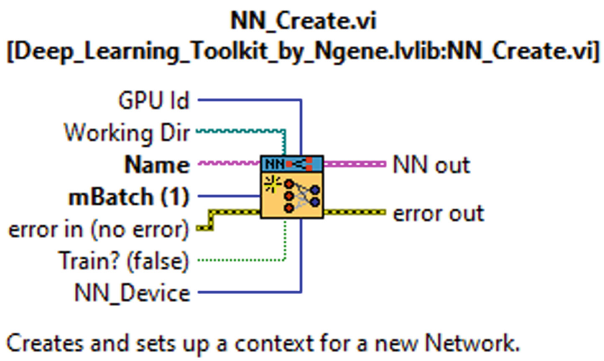

Fig. 3. NN_create.vi context help [Source: LabVIEW DeepLTK Help]

This subVI has only two required controls that must be wired – the name of the neural network (Name) and the mini batch size (mBatch) – which is by default set to 1. There is also another virtual instrument, NN_Create_From_CFG.vi, which builds a network based on the configuration network topology file, passed as a parameter.

The next step after creating the network is to create the layers of the neural network. A deep neural network contains many hidden layers. The order of the hidden layers can influence the efficiency of the network for solving the problem [10]. For creating the layers, we used the polymorphic NN_Layer_Create.vi, which creates the specified type of layer in the network.

For educational purposes, we used a machine learning system for speech recognition, based on a convolutional neural network that converts the 1D waveforms into 2D spectrograms by including also the frequency of the signal. For the training process we build a separate virtual instrument. As the first hidden layer of the deep neural network, we created a 3D input layer, having the GPU as the execution target. Then we defined several 3D convolutional networks and several fully connected layers for the classification. For all those layers we configured the activation function to be the Leaky Rectified Linear Unit (LReLU).

After building the model, we can start the training process by specifying the training configuration parameters. We created a while loop for updating the learning rate (using the NN_Cfg_LR_Decay_Policy.vi) and the loss value (with the help of NN_Eval_Test_Error_Loss.vi) after each iteration (Fig. 4).

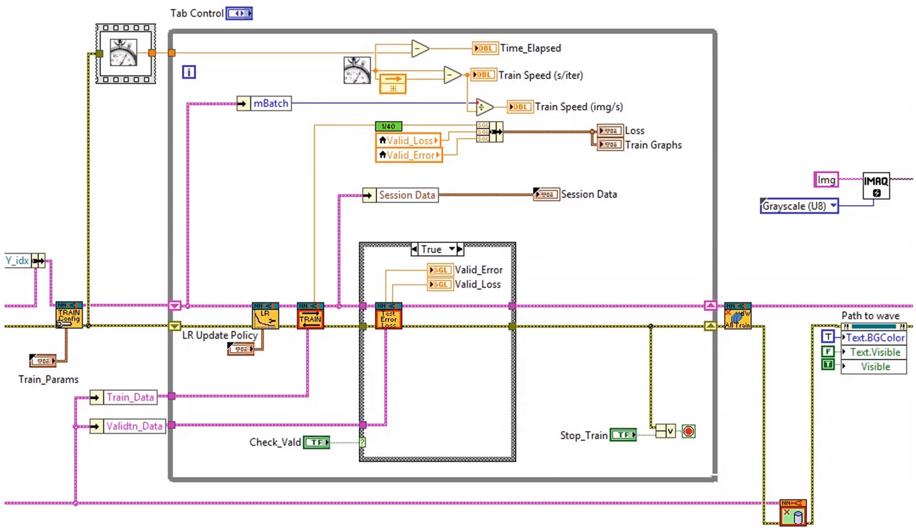

Fig. 4. Training the neural network (LabVIEW)

6 Testing and Deploying the Model

6.1 Evaluating on Validation Set

When it will finish the training, the virtual instrument (VI) runs into the testing phase, where we can test and validate the performance of the network. This is one of the most important steps, so the students should practice this step several times for getting a good intuition about this process.

After the VI runs into enough iterations, we can stop the training process if we noticed that the learning parameters (the training loss, the validation loss and the validation error) have decreased significantly, usually less than 0.07 [11]. We can use then the validation dataset to test the performance of the training process in the same virtual instrument we used for the training phase.

On the front panel we can also observe the predictions, the waveform graph, the spectrogram and the time was required to run the forward propagation step (Fig. 5).

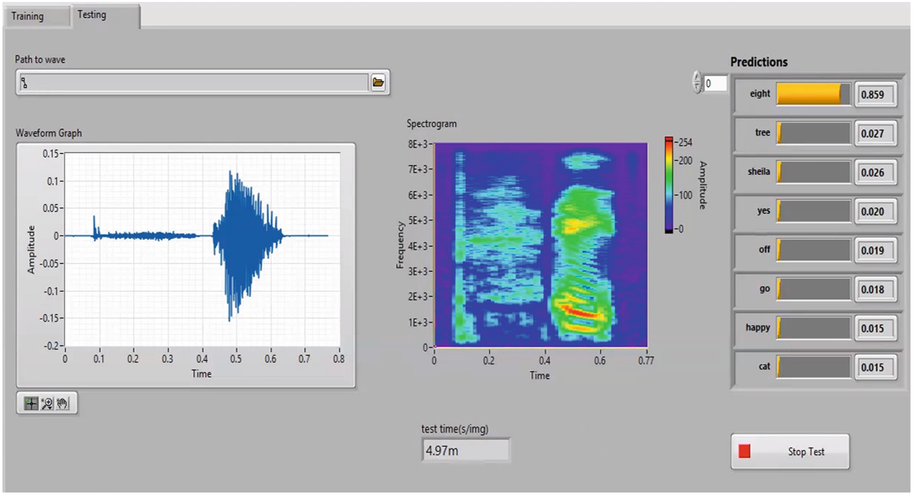

Fig. 5. Training the neural network (LabVIEW)

6.2 Testing the Model on Unseen Data

After finishing the training process, the toolkit will generate a set of files that can be used in the deploying phase. In the network configuration files (*.cfg* extension) are stored all the necessary information for reviewing the neural network, while the trained weights are stored in the binary files (.bin extension). There were some SVG files generated as well, where we can review the architecture of the network and analyze its complexity.

For the deploying phase we used a different virtual instrument in LabVIEW. In the front panel of this VI we need to provide the network configuration and the binary files generated during the training process. We can test the model either on already acquired audio data or we can acquire data in real time using the computer microphone. In this step it is important to evaluate how the model performs on unseen data, in order to have an unbiased view of the whole model [12]. The front panel looks very similar to the panel from Fig. 5 and has almost the same indicators. Furthermore, it also displays the test time and the test speed.

In the block diagram, we read the network topology using the NN_CFG(Read).vi, then we built the network based on the configuration file. We used an event structure to

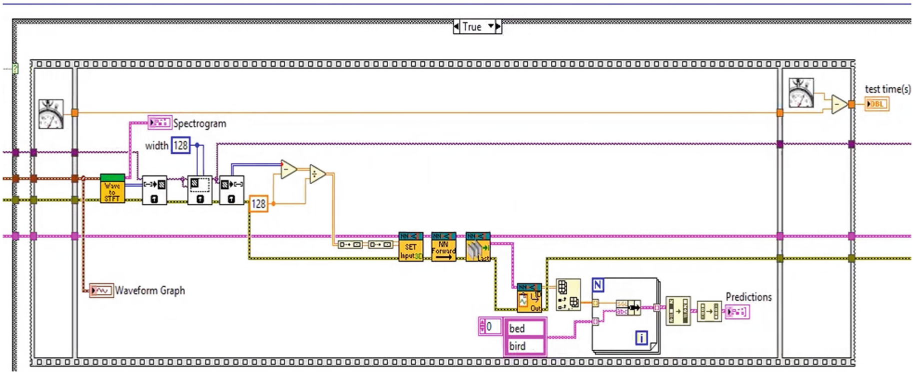

Fig. 6. Testing the neural network

test the trained network, where we specified also a threshold mechanism for the speech and run a forward propagation (Fig. 6).

After successfully running this program, the indicators and predictions were very accurate. The average test time (seconds/image) was around 3.31, while the test speed (images/second) around 290. Table 4 illustrates the prediction confidence for each term.

Table 4. Prediction confidence of the neural network

Term	Prediction confidence
Sheep	0.781
Up	0.148
Cat	0.106
Happy	0.041
Six	0.023
Nine	0.005

7 Conclusion

Because reskilling initiatives are a key part for a smooth transition to the 5th Industrial Revolution, it is very important to educate, as soon as possible, the engineering students and workers to acquire the necessary skills for the new jobs that will emerge. Despite that the employment landscape will definitely change, it may as well improve for many engineers, as the World Economic Forum predicted that more than 60 million jobs will come out in next years, because of the Artificial Intelligence and the technological progress. Therefore, AI is already augmenting jobs rather than displacing them. This study demonstrates how to use LabVIEW, together with the Deep Learning Toolkit and Python, for facilitating the learning process, to build a performant machine learning system from scratch.

The main outcome of this teaching practice is that, with the help of these learning methods based on AI, engineers will be well skilled for these new jobs that will be augmented by AI in the following years. Furthermore, they learn how to choose the best algorithm for their specific problem and how to create, train and deploy machine learning models that are now widely used in industry and daily life: in automation, self-driving vehicles, binary classification and medical diagnosis. This kind of approach, based on learning by examples and by comparisons with human intelligence, turned out to be much more effective compared to alternative methods.

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Using Competency Mapping for Skills Assessment in an Introductory Cybersecurity Course

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Abstract. Various courses and trainings aim to teach cybersecurity with only few measures for learning outcomes. Existing metrics such as general grades do not reflect the various competencies and specific outcomes that make up a course. More specific measures targeting competencies are needed: this differentiated approach must reflect course specificities, but also be general enough to be transferable to other courses.

This study presents a competency mapping approach based on the NIST NICE framework, demonstrated in a cybersecurity course on bachelor level. The approach enables to evaluate specific competencies and their relevance to various cybersecurity job roles. Additionally, this type of competency mapping can provide useful insights for designing and managing the course content in general.

Keywords: Cybersecurity · Skill assessment · Computer science education · Competency mapping · NICE framework

1 Introduction

Since the Third Industrial Revolution, which is generally attributed to computerization and web-based interconnectivity [1], there has been a growing demand for skills to operate interconnected computing machines in an efficient and secure way. However, there is also a reported shortage in the job market for people with cybersecurity competencies. Higher education systems are facing increasing pressure to produce graduates with relevant practical skills and competencies. This could be achieved by focusing more on competencies that are relevant in the job market [2]. In addition to giving a general course grade that reflects the summative level of achieving the learning objectives, a more detailed competency-based feedback could be provided. This would enable earlier identification of problematic areas for each student to reduce dropout rate and increase the quality of education. Also, it would potentially help to discover the hidden talents. These are individuals who have recognised difficulties in some cybersecurity-related topic areas but are unaware of their suitability for a different cybersecurity role.

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https://doi.org/10.1007/978-3-030-68201-9_56

The goal of this study is to systematically map the results of various learning activities to a specific competency framework, therefore creating an overview of the student's competencies. This enables a better understanding of the student's current performance compared to more generic grades that do not help to further analyse specific strengths and weaknesses [3]. Without competency mapping, it is much more difficult to understand what work role or topic area best fits the student. However, established individual competency profiles can contribute to early detection and intervention by targeting insufficient competency areas and identify or build upon existing strength to facilitate specialisation.

This paper builds on the general shift towards competency-based education [4] by discussing a case study of implementing competency mapping in an introductory cybersecurity course. The process follows the design science research methodology [5] of describing different design and implementation concerns. Questions from the knowledge tests and tasks from practical homework are assigned difficulty levels and are mapped into the NICE framework [6]. The resulting competency profile provides a deeper insight into both individual and course level.

2 Related Work

As shown by Frezza et al. [7], the term competency and competence are somewhat ambiguous. This paper is aligned with research considering the competency as a set of knowledge, skills, and dispositions [7–9]. More specifically, the focus is on measurements of knowledge and skills. Competency mapping is well aligned with the general shift towards a competency-based pedagogy [4]. Having a systematic approach for identifying and evaluating competencies is an important foundation of any competency-based course.

A considerable amount of literature has been published on curriculum mapping [10]. Ajanovski [11] introduces a visual domain exploration tool that shows personal progress against a reference body of knowledge areas. Gluga [12] explores the idea of mapping detailed degree requirements to individual courses and gauges each student's actual performance on assessment tasks. Auvinen et al. have created STOPS (Software for Target-Oriented Personal Syllabus) [13]. This enables a graph to be created showing how the topics taught in various courses are connected, and what each course contributes to the goals that the student has selected. Harris and Patten map various cybersecurity topics to courses in the IT curriculum [14]. To determine the expected proficiency level, they combine revised Bloom's Taxonomy [15] and Webb's Depth of Knowledge Model [16]. However, there is little effort to look deeper than the course level learning outcomes. While Gluga [12] mentions mapping students' actual performance, there seems to be no further published research based on real data.

Another set of research looks at the interdependencies of competencies. Frezza et al. [7] define a competency-based framework for learning to provide a structured approach to deriving and describing competencies. Deng et al. [17] use machine learning (natural language processing) to construct a cybersecurity knowledge graph from a Wikipedia database dump. Current study explores how competency mapping can add an extra dimension to the study of interdependencies. This enables an analysis of knowledge and skill proficiency evaluations based on individual results as opposed to a course level analysis.

3 Methodology

This research is using design science research methodology (DSRM) process [5] to present the process of competency mapping for skill assessment. The DSRM process consists of 6 steps: problem identification and motivation, defining the objectives of a solution, design and development, demonstration, evaluation, and communication [5]. The last step—communication—is done by this paper in general. The first 5 steps are discussed in the following sections.

3.1 Problem Identification and Motivation

To address the shortage of cybersecurity competencies in the job market, the educational processes must become more effective. Practical exercises are often part of a course contributing a fixed percentage to the overall grade. The final grade for a course is often considered as a performance indicator for a student. However, grade inflation occurs in many countries [3]. Universities are faced with the dilemma of whether it is more important to provide the maximum amount of students with a required set of baseline competencies or to ensure a normal distribution of grades. Normal distribution of grades would help better compare the proficiency levels of different students by avoiding a greater concentration of grades at the upper tail [3]. At the same time, allowing the performance of others to influence individual grades would further complicate the interpretation of the result as it becomes highly context-dependent.

In general, the grading of courses and the scoring of cybersecurity exercises suffer from a similar shortcoming with the lack of a meaningful interpretation of the results [18]. While it could be argued that a higher score in a cybersecurity competition and a higher grade in a cybersecurity course both signify a higher proficiency in the topic, a deeper analysis of underlying competencies is often difficult if not impossible. As an example, assume Alice and Bob both receive a grade 7 (out of 10) in a cybersecurity course. It is usually not possible to deduct from the grade whether Alice is more proficient regarding a specific learning outcome than Bob. That is because the learning outcomes of the course are rarely evaluated individually. Furthermore, the scores from theoretical knowledge tests and practical skills evaluations are often not differentiated. It is therefore often not possible to see whether a student has demonstrated good results in theory or in practical exercises, or in both.

3.2 Objectives of a Solution

The goal is to achieve more systematic overview of individual competencies of each student in a classroom education context. The method for achieving this goal includes the following:

1. Measured competencies should be structured systematically into categories and/or clusters.
2. Meaningful proficiency levels at the higher and lower level tasks should have a clearly defined qualitative difference and not just arbitrary "difficulty level".
3. Differentiation between the evaluation scores of knowledge and skills.

3.3 Design and Development

Following the objectives set earlier, the design process comprised the following phases:

1. selecting a suitable cybersecurity competency framework listing relevant knowledge and skills and/or topic areas;
2. selecting a suitable educational taxonomy for meaningful proficiency levels;
3. mapping the tasks in the course to the selected competency framework and assigning the proficiency levels according to the educational taxonomy.

Cybersecurity Competency Frameworks. While there are multiple initiatives to compile a list of subjects relevant to cybersecurity [8,19], the most commonly used tend to be the following three. First, a set of curricular recommendations in cybersecurity education (CSEC2017 [20], CSEC2020 [21]), released by a joint task force led by the Association for Computing Machinery and the IEEE Computer Society. Second, the Centers Of Academic Excellence In Cyber Defense Education (CAE-CD) [22] created in the USA by the National Security Agency and the Department of Homeland Security. To be recognised as CAE, a university must have a designated curriculum including a required set of knowledge units [22]. Third, the NIST National Initiative for Cybersecurity Education Cybersecurity Workforce Framework (NICE framework) [6] listing the knowledge, skills, and abilities that are needed for cybersecurity-related jobs.

In this research, the NICE framework [6] was used. This was because it is widely used both in research and in private sector. It also provides an extensive list of knowledge and skills suitably categorised into cybersecurity work roles enabling an assessment of student performance from a perspective of potential future work roles. The NICE Framework is comprised of the following components:

- 7 high level categories: Securely Provision (SP), Operate and Maintain (OM), Oversee and Govern (OV), Protect and Defend (PR), Analyze (AN), Collect and Operate (CO), Investigate (IN).
- 33 specialty areas: Risk Management (RSK), Software Development (DEV), Systems Architecture (ARC), Technology R&D (TRD), Systems Requirements Planning (SRP), Cyber Investigation (INV) etc....
- 52 work roles: Software Developer, Data Analyst, Program Manager, Vulnerability Assessment Analyst etc....

Each high level category comprises several specialty areas. Each specialty area contains multiple work roles. Each work role is connected to specific knowledge, skill, ability, and task items.

Educational Taxonomies. Several educational taxonomies have been developed to provide a shared language for describing learning outcomes and performance in assessments. Of these, the revised Bloom's taxonomy [23] is widely used. Fuller et al. [24] thoroughly analysed various taxonomies in computer science context and propose a two dimensional adaptation of Bloom's taxonomy—the matrix taxonomy. Niemierko's "ABC" taxonomy [25] as described by Strachanowska [26] and Fuller et al. [24] was chosen for this study. It aligns well with the concept of distinguishing knowledge from skills and at the same time limits the complexity of proficiency levels. A more complex taxonomy would require a deeper analysis of the particular context of specific learning outcomes and the classification can become problematic [24]. Niemierko's "ABC" taxonomy is generally aligned to Bloom's taxonomy by just combining the three highest Bloom categories into one. It is also somewhat similar to the single-loop and double-loop learning [27]. The single-loop signifies the repetition of the same strategy to solve a problem and double-loop emphasises critical self-reflection to generate creative solutions to problems [28].

Mapping the Tasks to Competencies and Proficiency Levels. To map the tasks to competencies and proficiency levels, 15 knowledge tests and 12 homework assignments of the course were manually analysed. Knowledge tests were divided into questions and each question was mapped to the relevant knowledge unit of the NICE framework. In this study, all 589 knowledge and 365 skill items listed in the NICE framework master KSA (knowledge, skills, abilities) list were used.

To map the 111 questions used during the course to 589 knowledge items in NICE framework, an initial filtering of relevant knowledge items was conducted. Initial filtering identified 75 knowledge items relevant to the course. Each question was assigned difficulty level of 1 or 2 based on Niemierko's "ABC" taxonomy categories A and B (see Table 1). An example of a level 1 question would be *"What does the letter A in CIA triad stand for?" (Right answer: availability.)* An example of a level 2 question would be *"Mary adds her digital signature to her essay. Which security aspect does it help to protect?" (Right answer: integrity.)* Answering correctly the level 2 question results in a proficiency point in both level 1 and level 2.

The tasks from the practical homework assignments were connected to relevant skills in the NICE framework. For establishing proficiency levels, each homework was assigned with thresholds for achieving difficulty levels 1 and 2 based on Niemierko's "ABC" taxonomy categories C and D. For example, the tasks in the reverse engineering exercise were connected to NICE skills *S0087—Skill in deep analysis of captured malicious code (e.g., malware forensics)* and *S0131—Skill in analyzing malware*. In this lab, students had to analyse executable files with increasing complexity. There was 1 executable program in Java, and 6 executables written in C. Solving the reverse engineering task for the executable written in Java gave students 1 point. Solving the reverse engineering tasks connected to executables in C, gave 0.5 points per task. The total possible number of points from the homework was 4 and the maximum proficiency level to related competencies was level 2. The reverse engineering virtual lab had the threshold of at least 1 point (out of 4) for achieving level 1 proficiency and the threshold of at least 3 points (out of 4) for achieving both level 1 and level 2 proficiency.

Difficulty levels determining the proficiency are summarised in Table 1.

Table 1. Difficulty levels based on Niemierko's "ABC" taxonomy [25] categories

Difficulty	Competency component	ABC taxonomy category
1	Knowledge	A. Remembering the knowledge
2	Knowledge	B. Understanding the knowledge
1	Skills	C. Application of knowledge intypical problem situations
2	Skills	D. Application of knowledge inunfamiliar problem situations

The summary of the designed process is given in Fig. 1.

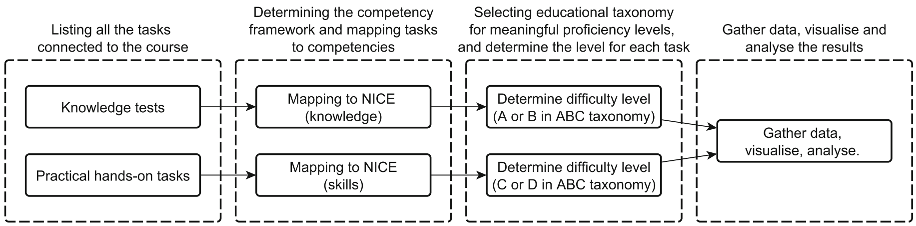

Fig. 1. Mapping process. Sections with dashed lines represent the generic steps for the described competency mapping method and sections with solid lines represent the steps taken during the current case study.

3.4 Demonstration

The case study was conducted in an introductory undergraduate level cybersecurity course with 106 participants. Performance scores were gathered from 15 knowledge tests that took place in Kahoot[1] environment during weekly lectures and 12 homework assignments. Every test and homework assignment contributed points towards the final grade. There were three types of homework assignments: 1 essay (evaluated by peers based on detailed criteria), 3 traditional assignments (manually graded report and/or software solution), and 8 virtual labs in a remotely accessible cloud-based environment (automatically scored).

[1] https://kahoot.com.

Knowledge was assessed based on a binary evaluation of Kahoot test answers (right or wrong) of each student. Each right answer gave 1 or 2 points according to its difficulty level (Niemierko's "ABC" taxonomy [25] categories A and B), contributing to the total score of related NICE knowledge units. Skills were assessed based on homework assignments. Results from home assignments contributed to grades (max 4 to 10 points depending on homework) and also to skill evaluations that was based on competency mapping to NICE framework.

3.5 Evaluation

In general, the method used fulfilled the set criteria. Measured competencies were mapped to NICE framework providing a well-structured systematic overview. Proficiency levels using the guidelines of Niemierko's "ABC" taxonomy [25] provided a good balance between simplicity and meaningful interpretation. Niemierko's "ABC" taxonomy also enabled knowledge and skill evaluation scores to be differentiated.

Figure 2 compares the results of Alice and Bob based on NICE categories and specialty areas. A detailed look into the performance of each specific area can help find potentially interesting and suitable areas for analysis. For example, it can be seen that Bob achieved good results (skill level 2) in Cybersecurity Defense Analysis (CDA), and Alice in Exploitation Analysis (EXP). While these insights are based on initial data and should be carefully analysed further, they illustrate how competency mapping can provide relevant ideas for future skills development.

The mapping process itself also provided useful insights regarding the course. From 589 knowledge items of the NICE framework, only 75 were considered to be relevant to the existing course. The rest of the knowledge items provide a good basis for considering additional topics that could be included in the course in the future. Also, out of the 75 relevant knowledge items, only 44 were actually measured by the quiz demonstrating a significant gap between the topics covered by the lectures and later knowledge measurements. For example *K0110—Knowledge of adversarial tactics, techniques, and procedures* was mentioned in several lectures, but never included in any test.

Additionally, the mapping provided the opportunity to see which NICE specialty areas were used the most during the course assessments. For example, Securely Provision (SP) category had a strong focus during the course while Investigate (IN) category was covered less (illustrated by the right side of Fig. 2).

Nevertheless, it should be noted that the NICE framework is a high-level framework and does not go into details regarding skills and knowledge items. Therefore, the mapping might not always adequately reflect the coverage of the concept. For example, consider a student that has completed a technical task mapped to NICE skill *S0130—Skill in writing scripts using R, Python, PIG, HIVE, SQL, etc.*. From seeing the skill, it is not possible to deduct what programming language was used. Furthermore, the level of proficiency is difficult to determine as the scope of "writing scripts" can be understood differently.

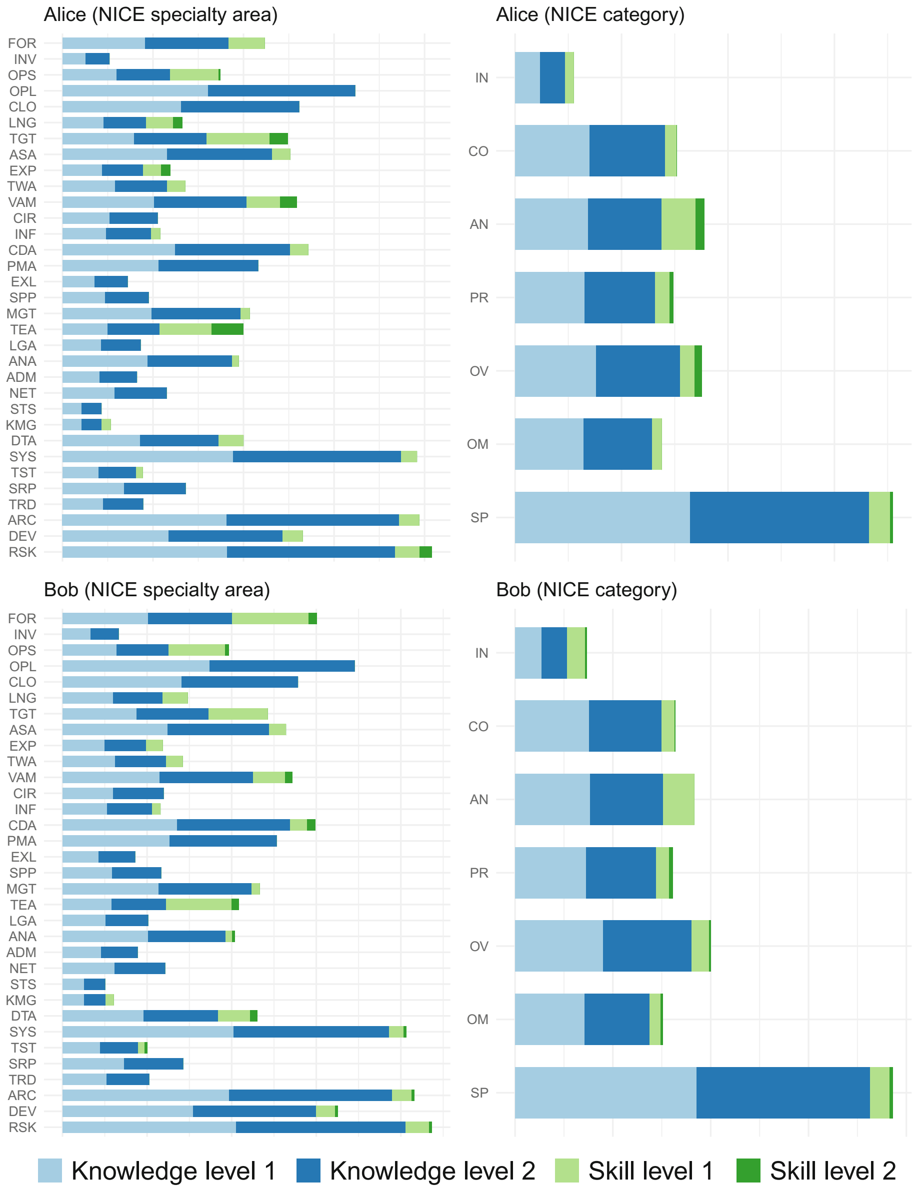

Fig. 2. Comparing the summarised results from two students using NICE framework specialty areas (on the left) and NICE framework high level categories (on the right). Please refer to NICE framework documentation [6] for detailed list of specialty areas, and categories.

However, some sort of ambiguity is inevitable because defining a competency with infinite accuracy is not feasible in most practical contexts.

Overall, the mapping method fulfilled its objectives and provided multiple additional insights as well as ideas for future research.

4 Discussion and Future Work

Mapping all the tasks included in the course to a competency framework was a time consuming, but rewarding process. Considering the competencies and specific measurements can help to focus the course materials, and assessments. In the future, automatic or semi-automatic approaches could be considered that would facilitate a faster matching of tasks to related competencies.

Many so-called soft or non-technical skills are more difficult to measure in a classroom context and especially in a scalable way (e.g., using an automated virtual lab). For example, NICE framework skills such as *S0355—Skill in negotiating vendor agreements and evaluating vendor privacy practices* or *S0356—Skill in communicating with all levels of management including Board members* are difficult to simulate and measure in any classroom context. Nevertheless, the importance of such transferable skills such as critical thinking, communication, collaboration and creativity [29] is increasingly brought out [18,30,31]. Although there have been attempts to measure non-technical competencies such as cyberethical behaviour [32] or teamwork skills [33,34], more research is required for specifying relevant non-technical competencies and developing assessment methods suitable for computer science context.

It is not possible to cover all the relevant cybersecurity topics in one course. There have been initiatives for bringing in cybersecurity topics into other computer science courses [35], social science courses [36,37] and liberal arts curriculum [38]. Aspirationally, a unified competency mapping could help track students' competencies throughout different courses. Cybersecurity competency frameworks could be combined with work on other computer science fields already having an existing body of knowledge [39] and taxonomies [40]. Similar approaches could be used in other fields as well potentially even in areas not directly connected to computer science.

This paper did not go deep into visualisation or usability aspects of competency mapping. Various user experience aspects of the competency map application will provide several future research opportunities. Approaches such as LATUX workflow [41] can be used for designing, validating, and deploying learning analytics visualizations Observing competency map assessments through time can give valuable insights about learning paths [42].

5 Conclusions

Competency mapping for skill assessment can provide a valuable input for various learning processes. An exploratory case study of competency mapping was carried out in a cybersecurity course where different learning evaluations were connected to the NICE framework. Preliminary results show that this kind of approach can be beneficial for planning and structuring a course's contents with regard to the levels of competencies reached by the students throughout the course.

Although this paper focuses on cybersecurity, a similar approach could be used in other computer science and engineering areas. In the future, similar competency mapping conducted across different courses has the potential to help curricular design and construct better learning analytics environments [9]. When applying a similar approach to several courses, a more comprehensive competency map can be compiled. Aspirationally, a granular competency map could complement the traditional higher education diploma and provide valuable insights for both graduates and their future employer. For now, the detailed process of competency mapping provides good basis to attempt similar approaches in other courses.

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Modern Mobile Interface for Remote Laboratory Control

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Abstract. The implementation of modern mobile interfaces for online laboratories is an urgent task because it allows increasing students' interest in such educational resources usage, especially in non-standard situations (for example, during self-isolation period). The results of Telegram messenger's chatbot development for interaction with remote laboratory Smart House & IoT are presented in this paper. It gives comfortable and effective tools and possibilities for the popularization of remote laboratory application for home automation technologies studying.

Keywords: Remote laboratory · Smart House System · Mobile Interface · Messenger · Telegram chatbot

1 Introduction

As known, online laboratories provide a lot of possibilities for industrial, health, and educational purposes [1]. Virtual and remote labs are actively used as effective tools for providing a learning process based on Internet technologies in different areas [2–4].

Further evolution of this direction requires studying the existing experience of already implemented projects and organizing the joint usage of already developed online educational resources and laboratories [5, 6]. The development of advanced methods of online laboratories hardware and software realization, issues of unification and standardization, as well as the improvement of user interaction interfaces with educational resources are still remain an urgent task [7–10].

Remote laboratory Smart House & IoT [11] is the specialized platform that provides possibilities of online studying of structural and functional features of the Smart House system (SHS). Traditionally, users work through the remote lab's web application (desktop or mobile versions) in an interactive mode with real equipment that can be observed online from a webcam. Nevertheless, the search for new approaches to the

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organization of interaction between students and remote laboratory (RL) hardware and software that are based on key capabilities of effective mobile technology is relevant [12].

Nowadays, users are increasingly refusing to use websites or web applications in favor of chatbots [13]. This is because they don't want to download the additional applications that take up memory of the device or store many web sites tabs. Users often prefer chatbots that provide the necessary functionality for them in the already installed messenger, which is actively used. All chatbots can be customized and configured for the user's needs or scope. The main advantage of the chatbot is the absence of the necessity to install the additional applications and registration because all popular and familiar messengers already contain this functionality.

Modern mobile messengers (WhatsApp, Viber, Telegram and others) are full-fledged communication centers that, in addition to messaging, implement voice and video communications, file sharing, and web conferences. Young people actively use them for communication in everyday life. Therefore, a promising option is the application of messengers to control RL experiments.

The goal of this work is the development of a chatbot for RL Smart House & IoT to popularize online experimentation, in particular, to motivate students for studying SHS.

2 State-of-the-Art

Traditionally, specialized desktop web applications are used to interact with RL. The mobile version of the RL web page can be also used as a mobile interface, through applying special styles to the size of the user's mobile device display. The examples of mobile versions of RL Smart House & IoT web pages are shown in Fig. 1. They are the home page of the laboratory, the virtual model of the stand with equipment, the list of available experiments, the examples of the experiment page "Solar Station" [14].

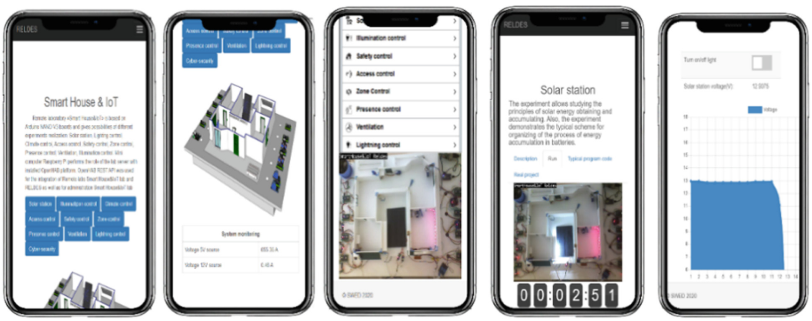


Fig. 1. Mobile version of RL Smart House & IoT pages

Interacting with RL using this approach is not very convenient, because users always need to scroll the page to search certain information. Besides, because of the frequent release of updated versions of mobile devices with different display resolutions, it is difficult to maintain the adaptability of the web application. This inconvenience is also typical for mobile versions of web pages of other remote laboratories. For example, well adapted interface of Labs Land [15] is shown in Fig. 2. Nevertheless, it is still inconvenient for the user to interact with this laboratory using a mobile device, as it is necessary to scroll the page to perform control actions and to see their results.

Thus, the search for other options for organizing a mobile interface to control RL is an urgent task. It is possible to use additional software that will be installed on the mobile device or to integrate the necessary functionality into existing software applications. The usage of a familiar messenger can be an option for solving the problem because it consumes less built-in mobile device memory and solves cross-platform issues. Messengers' chatbots provide a wide range of features that can be used to interact with RL.

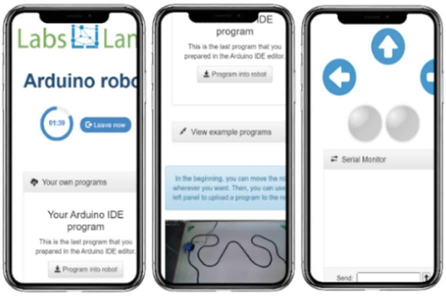


Fig. 2. Arduino robot experiment in the Labs Land

2.1 Investigation of Chatbots' Features

Chatbots are special feature of messengers that can play the role of a graphical interface to a service that runs on a remote server. In our case, an example of such a service is the online laboratory. Chatbots are created in order to handle and control messages automatically. The logic of the functioning of the chatbot is controlled by the handling HTTPS requests to the chatbots' server. Users can interact with chatbots using messages sent via regular or group chats. As control is carried out in the format of correspondence in a popular messenger and the principles of the RL chatbot are similar to other chatbots in the network, it will be easy for the users to understand the principles of its functioning. The existing experience of users with the messenger will contribute to the effective usage of the chatbot for interacting with RL and performing remote experiments.

Investigations have shown that many chatbots are in the Network today, which differ in the form of interaction with the user, purpose, quality of implementation and so on. Table 1 shows the results of the chatbot type's overview [13, 16]. The next types of chatbots have been selected for the future implementation as a result of the analysis: Functional chatbot, because it gives the current task solution; Menu/Button-Based chatbot, because it allows to make interaction with the RL comfortable; Bot-helper chatbot, because it will be useful for users to get the actual information on the current remote experiment. Messengers such as WhatsApp, Facebook Messenger, Viber, Telegram, Skype, Sender, etc. have announced their support for the chatbots. Because all messengers are developed on different platforms and have different APIs, it is necessary to create a personal bot for everyone. As a result of the analysis of the chatbots' features for different messengers the following features were found.

Table 1. Chatbot types.

Chatbot types		Description
By human interaction	Menu/Button-Based	The bot uses buttons and commands to interact with the messenger's interface, but instead of sending it a normal text message, the user must select from the proposed list of actions. After selecting the desired button and clicking on it, the bot understands it as a command and executes it. Such commands are assigned when creating a bot
	Contextual Chatbots	The bot can give the result not only to prepared questions, but also to recognized human language. Thus, the bot can analyze the request by a set of words and can give an answer in the format of a dialogue. Due to this, communication with such the bot is as close as possible to the reality. These bots are based on language recognition systems in their work. Buttons are also used for faster navigation
	Keyword Recognition-Based Chatbots	Such bots can be called in any dialogue, just wrote: "@ nickname of the required bot". Then the bot will be opened in a dialog and offer its functionality. The result can be immediately sent to the interlocutor by selecting the necessary actions
By appointment	Communication chatbots	They speed up the communication process between the user and the company. More often, such bots are designed to answer frequently asked questions. The user lists them and the bot displays the answers to them. If the question is written manually, the bot will try to recognize it, in case of failure it will offer to call the call center, to order a callback or to go to a chat with a manager for dialogue
	Marketing chatbots	This type of communication bots replaces the usage of communication channels such as E-mail or SMS, with channels in the form of correspondence in popular messengers. The main task of such bots is to inform users
	Functional chatbots	They are used as a replacement for mobile applications or web sites
By functionality	Bot-helper	They perform the role of technical support and respond promptly to users at any time. These bots can control personal data and inform the user about available offers
	Bot-content maker	These bots are designed to inform users by sending important information or data on a specific request
	Bot-entertainment	They are designed to entertain users with jokes, funny videos, etc. In such a way, an offer of a product or service in this form is not imposed but offered

In Facebook Messenger, the chatbot is based on personal messages from a public page on behalf of the user. To create it, it is necessary to create an application for access to API and a public page. The bot can interact with users via text messages, through “Structured Text”, which allows using buttons, elements, and invoices (for payment) in a dialog [17].

For Viber, the bot is created through public accounts for the company’s interaction with the user. The buttons and bills are standard functions. Additional functions include the ability of the bot to send data to any contact. For this, user needs a registered number on Viber as well as the ability to send a message like “carousel”, where each element contains a photo of the product, description, price and a “buy” button. An admin panel is provided to control the bot, but the custom bot has limited functionality, and it’s necessary to contact the developers to expand the bot’s set of functions [18].

In Skype, a text chatbot uses the same message elements as the other bots (buttons, elements and forms of payment). The “menu” function is presented, which lists the capabilities of the bot. Using Skype bot API, the Cognitive Service Language APIs provide the bot with such function as building of assumptions about a query based on keywords in the text, when the bot uses the context and experience about queries that were earlier from this or other users. Another function is the independent generation of full conversational answers. The bot can be integrated with Google Analytics [19].

In Telegram, interaction with bots is happening via sending a message and command to bots, opening a chat with them or adding them to groups, as well as sending requests directly from the input field by entering @username of the bot and the request. Messages, commands and requests sent by users are transmitted to software running on users’ servers. The Telegram proxy handles all encryption and communication from its API. Chatbots are created using a specially created chatbot BotFather [20].

Slack is a corporate manager suitable for business or team communication. The platform provides the ability to create chatbots of two types: bots for the user and applications. The first one exists only in Slack, it can be added to dialogs or groups. It focuses on helping in communicating inside the company. Moreover, the second type of bots can act as a separate mobile application that uses the Slack interface and integrates with the messenger [21].

Thus, the analysis has shown that the functionality of many chatbots of messengers is limited or it is required payment for its expansion. Therefore, Telegram was chosen as the messenger for chatbot creation. This decision was due to the high popularity of the messenger in our country, as well as its full functionality and possibility of chatbots free of charge development.

3 Implementation of Chatbot for RL Smart House & IoT

The functional requirements for the developed chatbot were the following: eo authorize system users; to provide a list of commands grouped by content for easy control. to provide information about the status of experiments, the separate ones or altogether. to provide instructions for the correct performance of educational tasks. to send program code to certain experiments. To add users to the lab queue. to inform users about the availability of remote experiments. to recognize failures.

The architecture of the designed system (Fig. 3) is built on the concept of API Webhooks [22]. In this architecture, the server provides an endpoint of its API, to which a response will be sent in the case of updating data.

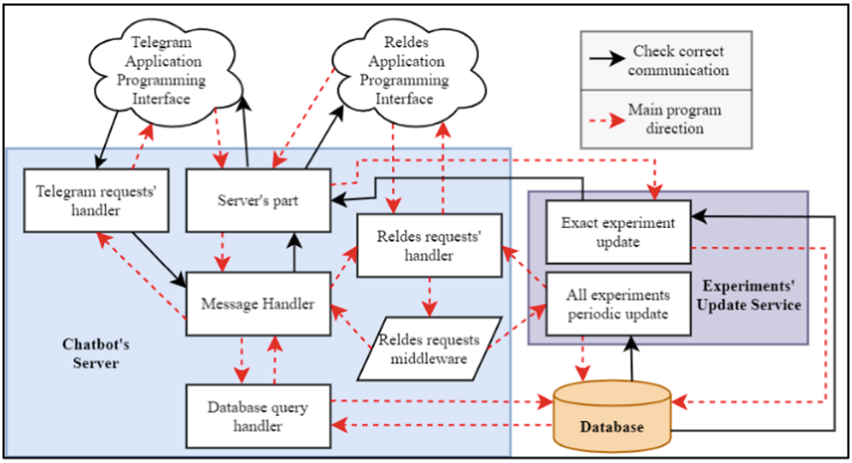


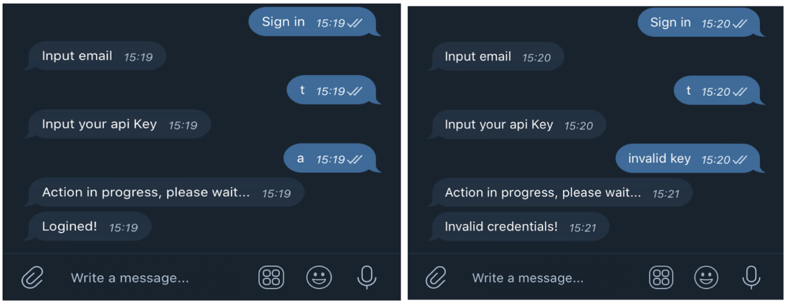
Fig. 3. System architecture

The project was implemented in the Python programming language. This language has a flexible and understandable structure due to PEP's code writing standards, a large database of libraries for the development of server software applications for interaction with all modern databases. In addition, Python allows interacting with third-party web application APIs and it has one of the largest communities.

It was decided to use the MongoDB as a database for the project because it is a non-relational database, which has a high-load functionality and well-written documentation. It spends a few server resources and provides a good community and support of developers. The file system was planned and the Docker-compose containerization system was configured. Due to this, the developed software product can be easily and quickly configured and deployed on the server.

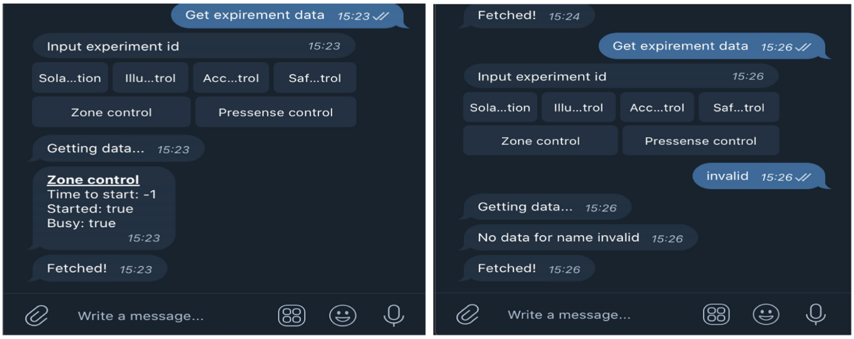
The developed software interacts with the administrative subsystem of the RL. During the development, a specialized test API was created that simulates responses from the RL administrative subsystem to prevent system failure and user data loss. The RL chatbot provides control of user actions and the handling of errors. The examples of successful and unsuccessful dialogue with the user are presented in Fig. 4 for the user's authorization and in Fig. 5 for getting data from the remote experiment.

Due to the quarantine, it was problematic to deploy the chatbot at the real laboratory server, so it is communicating with the specially developed testing server, and for the authorization 't' is used as a correct email and 'a' as an API key.



a b

Fig. 4. Screen forms of successful (a) and failed user authorization (b)



a b

Fig. 5. Screen forms of successful (a) and failed (b) getting of remote experiment data by the name in the chatbot

4 Conclusion

The creation of a special mobile interface for Smart House & IoT RL control in the form of the chatbot is the result of this work. The detailed list of commands, which are grouped by content for easy control, has been developed. Due to these commands, the user will be able to obtain information about a particular experiment or all experiments, available in the RL, to take a queue for the experiment as well as to send a control action to a specific experiment.

The organization of queues for experiments and a user authorization system are implemented based on interaction with RL API. Thus, in the case of changing the logic of authorization or working with queues, the RL chatbot will contain automatically the latest version of the implementation without the need to update the program code. The Telegram messenger's API requests the processing, which is based on the Webhook technology. This technology allows multi-user support, which in turn provides the ability of automatically storing users' data in the database and controlling them during their authorization.

In the future work, the functionality of the RL chatbot can be extended by sending metrics of the current experiment to the user, and also by further improvement of the interaction between RL Smart House & IoT and the developed chatbot.

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Master's Degrees in Russia: The Reality of the Bologna System Implementation

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Abstract. This paper identifies the master's students' attitudes to the effects of Bologna reform in Russia. The core idea is that the main challenges in Bologna Process implementation in Russia are connect deeply with the quality of human capital. Conclusions were based on the results of a large-scale survey, conducted in 2019, in 19 Russian universities. The authors examined the shortcomings of higher education reform at the micro-level. Data demonstrates that the reform provided a real opportunity for students to change their education track; work experience is more important for employers than master's degree; master's students enter the labour market as early as possible; master's students are not eligible for entrepreneurship and collaborative group work skills; most master's students believe that hard skills are crucial for any future job. The transition to a two-cycle system is assessed rather negatively, both by students and teachers. This paper also opens a discussion for more use for the Bologna reform implementation sustainable development framework.

Keywords: Master's education · The Bologna system implementation · Education policy in Russia

1 Context

Development of a European Higher Education Area (EHEA) has attracted much attention in the last 20 years. In the early 2000s, there was an incredible drive and optimism in Bologna system implementation: the first decade could be titled as the Fast Start. This was followed by a period of disillusionment.

The Bologna Process (BP) created not only formal rules, needed to implement a higher education system, with new context and system-level changes. These changes showed that harmonisation was not achieved through existing EU schemes of education. Some members tackled the fundamental values on which the EHEA was built. In this regard, Russia is an especially interesting case of the Bologna process.

The Bologna system, which currently unites 48 countries, provides a framework for international cooperation between universities and facilitates the dissemination of the best regional experiences in higher education. Its official goals are the creation of a common space for higher education in Europe and the provision of new opportunities for graduates to be employed in the EU labour market, the participation of Russia, in the European space of higher education, might potentially increase the brain drain.

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Therefore, the Bologna system is a challenge as well as an opportunity to improve the quality of education. Russia entered the Bologna system in 2003, to harmonise with European education standards. The Bologna reforms were gradually introduced into the Russian Higher education system (HES), starting with a 3 - level structure, so that now there are levels of Bachelor's, Master's and Ph.D studies. "Specialists" degree also exists, but they are a minority.

Changes in higher education in Russia are continuing very dynamically. Russian universities (especially regional ones) did not always keep up with them, which led to the situation when the credit system and the idea of the two-cycle education have been lost among the formal indicators. As a result, the normative "framework" was ahead of the processes that it should regulate. There is a lack of communication between all stakeholders (students, teachers, administration, employers, government). So, it is critical to understand how they see the results of the higher education reform (bottom up effect).

2 Purpose

Bologna process implementation in Russian Universities is a problem that needs further investigation. Note that, we focused on master's education as a new element of Russian higher education and its social effects. The social effects of a master's education are not the same as the results of the education (i.e. "competences"). Social effects can be referred to as the changes in the labour market, public government, and quality of social capital.

The purpose of this article was to clarify if Bologna reforms in Russia led to a new quality of human capital as one of the key points of sustainable development.

To be more specific, this research intends to contribute to the discussion of the following questions: (1) do Russian employers demand a master's qualification for higher - level positions and (2) are the master's programs get the innovative competencies for the students?

To answer these questions, we must take a closer look at the effects of the education reforms in master's education, to find the gaps in awareness and understanding of the education values, relating to sustainable development among students in Russia [2].

3 Conceptual Framework

Education quality in the Master's programs has become one of the most contentious issues since 2011. According to previous research, three main areas are the most complicated at this point: the labour market, teaching and learning practice and the education planning process [1]. Employers do not know what the differences between bachelors and Master's are and why they should pay more for the second one. What new competencies should a new Master's degree, different the previous national 5-year specialist degree, given to students?

The survey was focused on the understanding of what the real model of the Master's education is in Russia, and how it corresponds to the sustainable development goals. Russian experts view sustainable development as a combination of three main components: resource-efficient economy, environment protection, resolution of social problems and human capital development [3]. The latter is the most interesting to us because it offers the best means of observing Bologna reforms effects.

Many European countries are actively involved in efforts to implement the strategy of education for sustainable development [4] included in the framework of the Bologna process [2].

That is the point of Erevan Communiqué (educational opportunities provide the competences and skills required for European citizenship, innovation, and employment.) [5]. Thus, business needs innovative skills from new leaders [6]. This means that the higher education system needs to provide a new quality of education to support skills development for employability among the graduated students [7].

We believe that a social capital approach is a suitable framework for understanding whether the higher education reform in Russia led to sustainable development or not. Social capital is the main resource for aggregated economic growth, in that global trends demand new qualities of human abilities. Social capital is a concept which focuses on real-world links between groups or individuals which network together with shared norms and values. We use the term to mean a person's ability to transform social structures and institutions, make improvements in the world through collaboration with others. Social capital involves soft skills, hard skills, noncognitive traits (as well as grit, perseverance, psychological adaptability, etc.) [8].

4 Methodology and Type of Data for the Analysis

We feel that the Bologna reforms could lead to the new quality of education and human capital. This paper identifies the effect of a higher education transformation on the strategies and attitudes of master's students. In order to collect and analyse data to answer the research questions we developed an empirical study aimed at: (1) getting data about the quality of human capital from the respondents, (2) analysing beliefs about what Master's study is used for, motivation, education tracks, and opinion about Bologna reform in Russia.

We need to clarify that education tracks involved choices during the education (variable courses, lecturers) and mobility involved both international and internal one (changing the University, moving to another city, etc.).

As for human capital, we believe that new quality means that, for modern young people skills, knowledge and ability are more important than a high salary. In addition, we also studied expectations about the chosen program, employability, future profession and skills upgrading during Master's studying. The micro-level: this is the place where individual educational measures, with their planning, realization, and results are found. On this level, teaching and learning processes take place. Learners get opportunities for participation and action on sustainability issues [9].

The paper describes the results of the large-scale survey, conducted in 2019, in 19 Russian universities. The data are obtained from a survey carried out by the members of the project “Russian Master’s early growth”. This was a self-administered survey (i.e., the participants complete the questionnaire themselves) - 3,500 bachelors, 1,140 undergraduates’ students and 700 teachers. The project covered the regions of the Central, North-Western, Southern, Ural and Siberian Federal Districts. The study includes regions with different levels of economic development. The number observed was determined by the total quota sample of the study, which involved both undergraduates and bachelors, as well as faculty members.

The survey contains indicators of two social groups (students and teachers).

The students: socio-demographic characteristics (age, income, parental education, etc.); learning motivation, features of self-determination (reference groups, value guidelines, etc.); the trajectory of admission to the educational program; educational migration; educational and career strategies; expectations from the program; satisfaction with education.

The teaching staff: socio-demographic and professional characteristics (age, income, length of service, etc.); key characteristics of the programs in which they are involved; involvement in education program development; approaches used by teaching staff in the educational process; subjective assessment of the success of transformational processes in higher education.

Table one shows the descriptive statistics of the variables for master’s and bachelor’s students. 31% of master’s students were male; 77% of them was aged 20–24; 75% of students studied on state-funded places and 71% of master’s students worked during their studies. Only 29% of master’s students chose not to work during the year of the survey. Most of the students had close relatives (parents) as a source of payment for their education (82%) (Table 1).

Table 1. Statistics of the variables for students

Variable	N	Mean
Master’s students		
Male	1140	0.31
Age	1140	22.5
State-funded	1140	0.75
Worked during studies	1140	0.71
Bachelors		
Male	3500	0.33
Age	3500	20
State-funded	3500	0.56
Worked during studies	3500	0.62

Table two shows the descriptive statistics of the University teachers variables (Table 2).

Table 2. University teaching staff description

Variable	N	Mean
Male	700	0.26
Age	700	45.5
Degree (doctor/candidate/PhD)	700	0.88
Federal University	700	0.14

To estimate the effects of two-cycle education, a common approach is quantitative analysis, using description statistics and crosstabs.

5 Results

We divided the results into several sections: education track, motives, employability, skills, and bologna reform acceptance.

5.1 Education Track

According to the study, most undergraduate students in Russian universities continued their education as master's immediately after graduating from the same university, where they studied before. 55% of them changed their specialty into a different one, and 45% continued to study in the same.

Most of the 55% took time out - gap years, or longer, before continuing their study. In the first group of undergraduates, there were more fee-paying students. Those who did not take a break in education are the students receiving free education, and 79% of them did not change their master's program to the related area or other. We found out that the most significant factor that divides our sample into different groups was a time gap between bachelor/specialist graduation and entrance to the master's program.

Figure 1 illustrates the distribution of the sample in answering the question "You entered into a master's program after…" and has an additional chart showing those master's students who prolonged their education after 2 years or more.

The graphs focus on the comparison of two groups: those master's students who had a break after the first level of education and those who did not. Those students who continued their study without gap years or after 1 year after graduation mostly chose the same master's program specialisation.

We examined whether the motives for getting the master's degree vary in these groups or not.

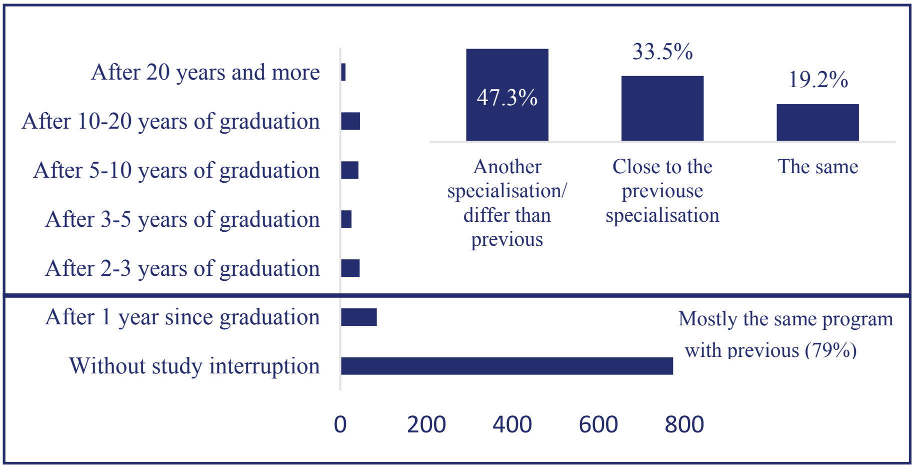

Fig. 1. Variances in answering a question "You entered into master's program after…" among a sample of Master's students

5.2 Motives

The next aspect is a range of the students' motives and their expectations concerning the master's education outcomes. The change of the educational track turned out to a significant indicator for the sample. Therefore, we built cross tables to find out how the groups with different, similar, or the same chosen master's programs are distributed (Table 3).

Table 3. Motivation for studying among the sample of master's students

Motivation for the further masters education/Master programm in comparing with the previous one	Different	Similar	The same
Self-expression, self-devlopment	51	66	98
Academic track	14	18	46
For higher salary	18	28	82
For foreign mobility	4	2	8
For better career prospects	39	126	207
To get a full education (like "specialist")	0	0	1
To get a new specialisation	139	77	14
It was a spontaneous choice	8	7	29

Those Master's students who wanted to get their education abroad and a new specialisation changed their education track. Most of those who wanted a high salary and better career prospects did not change their specialization. Those respondents who have a specialist diploma entered the master programs guided by the motive of self-development or change of a professional field.

5.3 Employability and Skills

We have found that the problem of students' employability in the context of master's education outcomes is too significant to ignore. Some conclusions and correlations were quite unexpected in self-estimates of employability skills among the students. For example, 54% of surveyed bachelors and 51% of master's students believe that there is no difference between a bachelor's and a master's degree for a potential employer. The table below illustrates variances in answering the question if an employer asked about a master's degree during the interview for a job position (Table 4).

Table 4. Master's degree importance for the employers

How often employees asked if you have a master's degree	Master's' students, %	Bachelors, %
Always	3.0	3.0
Rarely	20.0	17.0
Never	67.0	66.0
Very often	10.0	8.0

Table four shows only the students' experience.

Important conclusions had nevertheless been made, as most students said that they worked during education. However, more than 60% of surveyed students stated that education will help them to get a good job. Why?

Interviewed students do not want to get new knowledge and skills, but they are counting on getting a higher salary because of the obtained master's diploma. They link this stance not to a master's degree per se, but to the experience gained by working during education at a master's program. Most undergraduates suppose that the employer does not care if you graduate or not, but work experience is important, so they try to enter the labour market as early as possible.

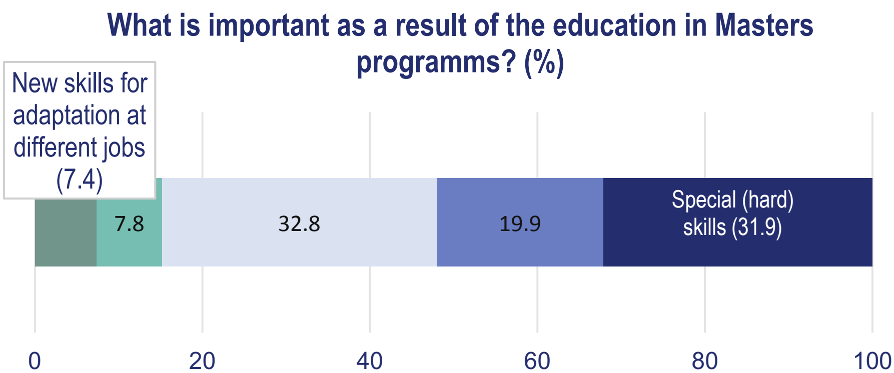

Fig. 2. Soft and hard skills of master's students

The stack chart into Fig. 2 is divided into 5 parts which show those master's students who agree with the idea that new skills for adaptation at different jobs are important (green charts) and those who think that hard skills are crucial for the employees (the blue chart).

Table five indicates the hard skills deficiency. Also, we indicated that master's students are not eligible for entrepreneurship and group work (Table 5).

Table 5. Competences and skills self – appraisal among Master's' students

Competences and skills	Scale, %	
	Not enough yet	Built enough
Entrepreneurship	66.8	33.2
Group work	50.9	49.1
In-depth competencies (hard skills) from the professional field	48.6	51.4

At the same time, most respondents do not have plans for doing business. The "top-three" areas include work in the public sector, practical work in commerce (but not entrepreneurship), and managerial positions in the commercial sector (Table 6).

Table 6. Areas where master's students are planning to work

Planning employment	Scale, %
Manager in the commercial sector	16
Practical work in the commerce	19
Entrepreneurship	12
Work in the public sector	22
Academia, research	15
Government	11

5.4 Bologna Reform in Russia: Acceptance Among Students and Teaching Staff

Next, we turn to the last, but not the least indicator of the Bologna reform outcomes, which is the acceptance of the idea that the reforms were successful and necessary.

The results showed that 59% of university teachers consider the transition to a two-cycle system as an unsuccessful reform (the workloads, academic demands, and competition are increasing, but the positive effects are weakly visible). Bachelors and master's students are more optimistic: only 31% of bachelors and 32% of Master's agree that the reform was unsuccessful, and 69 and 68% of master's and bachelor's students respectively consider this reform successful and rather successful. The pie charts below compare the respondents' attitudes to the Bologna reforms in Russia (Fig. 3).

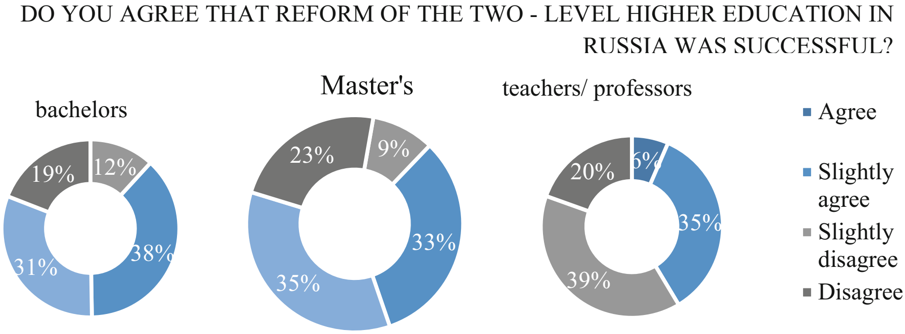

Fig. 3. Students and university teaching staff opinions on the Bologna reform in Russia

It may be concluded from the pie charts that a significant number of undergraduates are little informed about the Bologna system. The interesting fact that those, who are not familiar with it, assess the reform rather negatively.

Summarizing the available data, we marked a few key points. Education track and the gap between the bachelor graduation and master's program entrance is the significant factor in choosing a further specialty and professional plans. Those Master's who took a break before entering, changed the course of study, entered for the sake of self-realization or in order to continue their studies in graduate school, have a positive attitude towards the reform, and transition to a two-cycle system.

According to the students' opinion, work experience is more important for the employers than skills. That is why master's students in Russia enter the labour market as early as possible. Master's students are not eligible for entrepreneurship and group work skills. Moreover, most master's students believe that hard skills are crucial for their future jobs.

Assessment of the reform is related to whether respondents know something about the Bologna reform or not. Teachers evaluate the success of the transition to a two-cycle system more negatively than bachelors and master's students. No significant statistical relationship between the attitude of teachers to reform and other indicators (gender, age, work experience, university, degree of participation in the development of master's programs) was found.

6 Discussion

What are the early results of the implementation of the Bologna System in Russian Master's education? According to our research, there are no differences for business leaders if their employers are bachelors or have a master's degree. A master's degree in Russia is implemented mainly for public administration and state employers. The better position of master's graduates is explained by their age and work experience. Therefore, a large number of master's and bachelor's students work during their studies, to gain experience and not to earn money. For students, the second level of higher education becomes an instrument for improving relevant skills. They see a real opportunity to gain additional skills in another professional field building up hard skills. It is crucial to augment a range of Master's programs with the entrepreneurship and soft skills subjects. Higher education systems in developing European countries reacted to the increased demands of soft skills and human capital development, for instance, increasing the share of students studying humanities, and spreading the liberal arts model (Telling, 2018) [10]. In this model, soft skills became core competencies for master's education. In Russia, students opted for a continuation of their education in Master's' programs to obtain hard skills, which they can use for a long time without improving their professional credentials. The transition to a two- cycle system is assessed rather negatively, both by students and teachers.

The academic Master's must be roughly linked with the scientific teams, the existing capacities for preparing doctoral thesis and their integration in research process. The creation of practical (professional) Master's must be justified by the economic context and labour market demands.

The main barrier to the development of a master's education in Russia is a lack of trust in the educational outcomes among both teachers and students. We consider this as a threat to the sustainable development of Russia's educational system.

Apart from the findings of the social survey, our paper presented discussion about the decision making and changing attitudes to measuring educational outcomes and organizing the educational process.

Firstly, local and regional master's programs should be strictly oriented toward the local labour market demands. However, it has become a tool for keeping young people in the study process while the labour markets continue to shrink.

Secondly, we believe that modern Russian graduates need to get some time off to decide what to do next. Additionally, they need to continue expanding the sets of relevant skills and competencies during their education.

Finally, students require practice-oriented training programs with the ability to quickly enter the labour market with a higher starting position and salary.

7 Conclusions

In conclusion, our analyses of how postgraduate students understand the Master's degree role in their career and education track, show that the implementation of the Bologna reform would take more time before it brings visible results. This is a common trend for all post-soviet countries, implementing the Bologna reform [11].

Changes in the Russian higher education are continuing very dynamically. Russian universities did not keep up with them, which led to the fact that the essence of the credit system and two- cycle education was lost behind formal indicators.

Focusing only on implementation is not enough, we need to build new practices of communication between students, teachers, administration, and employers.

This paper contributes to both empirical and policy-oriented topics. The main result of our paper is that it provides more convincing evidence of the micro-level outcomes of the reform in Russian higher education.

The role of higher education became more and more significant in the challenges we face: the threats to our environmental, societal, cultural, political, and economic sustainability. The current situation requires high adaptability from students, while not giving a feeling of confidence in the future. This confidence should be formed by education.

This research gives a better understanding of the necessity of including students to the education co-management, implementing new teaching methods, oriented to the labour market and the entrepreneurship education for all master's programs. These key changes are relating to sustainable development.

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Task-Based Mobile Learning ISC-System: Built-In Coronavirus Immunity Confirmed

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Abstract. The interruption of contact group work in universities due to coronavirus quarantine in the spring semester of 2020 posed serious problems for all courses that used traditional approaches to organization laboratories, control tests and examinations. In contrast to this, the mobile task-based learning ISC-system, characterized by flexible individual time schedule planning and application of mobile home lab kits for practical tasks, demonstrated almost complete immunity to emergency isolation requirements. ISC is a task-based e-learning system developed in Tallinn University of Technology since late 90s (abbreviation ISC comes from code of Chair of Circuits and Systems). In this system a learning process without teachers' continuous interference is implemented and the students can practice as much as needed to get the grade they desire. As an additional beneficial feature, system allows teacher to monitor the detailed activities of students related to solving the hundreds of theoretical and practical tasks associated with actual study course. In paper we formulate the key features of the newest 3rd generation version of ISC-system, provide an assessment of immunity of ISC-system key features to quarantine conditions and present a study of student behavior changes due to the quarantine conditions on the basis of more than 216,000 task solving records from years 2019 and 2020.

Keywords: Task based learning · Competence based learning · Mobile home laboratories · Flexible timeschedule learning · Student data analysis

1 Introduction

Due to the COVID-19 crisis and following the actions taken by many countries, on March 12th 2020 the Estonian Government established the quarantine rules that recommended to cancel all public events including classroom work in schools. Universities were forced to switch to distance learning that lasted actually until the end of the spring semester in June. Those special circumstances revealed that surprisingly many teachers, using still traditional learning technologies, faced noticeable difficulties with organization of practical laboratories, control works and exams in classrooms with fixed time schedule. From viewpoint of modern IT-supported teaching technologies, these time- and space-limited student progress control methods can be considered as unnecessary bureaucratic waste of time that takes away teacher's time from creative

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supervision or task design work. In contrast to abovementioned difficulties faced by courses relying on traditional approaches, the mobile task-based learning ISC-system [1–8] with mobile home laboratories and flexible individual time planning demonstrated almost undisturbed functioning in emergency isolation conditions.

In the present paper we touch the following themes:

1) A detailed classification of innovative key features of task-based mobile ISC-system in order to give the reader a basis for comparison with other learning systems and to prepare a logical structure for user satisfaction surveys for the system improvements in future;
2) Assessment of quarantine readiness of ISC-system using the constructed list of key features;
3) Study the student behavior changes due to coronavirus quarantine on the basis of more than 216000 task solving records from years 2019 and 2020.

2 Characterization of Task-Based Mobile ISC-System

Actually the development of interactive e-learning technologies in Department of Computer Control at Tallinn University of Technology (TUT) by the working group of Prof. Vello Kukk was started already in 1998 [1]. At that one of the main ideas was replacement of traditional lectures and exams based learning with solving of large number of tasks online.

In the 2003 the online evaluation of answers and systematic storing of test performance records in database was started that may be considered the launching time of the 1st generation of ISC-system [1, 6]. Abbreviation ISC comes short code of former Chair of Circuits and Systems in Department of Computer Control. In 2005 the first version of Home Laboratory Kits (HLK) and in 2007 the 2nd version of HLKs were introduced (see Fig. 1).

Fig. 1. Home Laboratory Kit of ISC-system. The crucial hardware component of the system to ensure the site-independent learning.

With introduction of HLKs the ISC-system acquired an important mobility feature that ensured that the same practical test tasks could be performed by students at home, in training lessons and also in control works in university classroom [1]. HLK contains components for basic electronics including signal generator and oscilloscope or optional microprocessor programming board [9].

Starting from 2010 the competences based evaluation (in contrast to subjects based evaluation) and the opportunity for self-decided grade acceptance (i.e. free individual course ending choice) were offered for students [2–6]. This may be associated with development of 2nd generation of ISC system that ended in 2017 [2]. Competence-based assessment forces students to penetrate more into the content of tasks and makes more difficult mechanical memorizing of the correct answers. The introduced volume-quality map for self-decided grade acceptance is illustrated by Fig. 2 below.

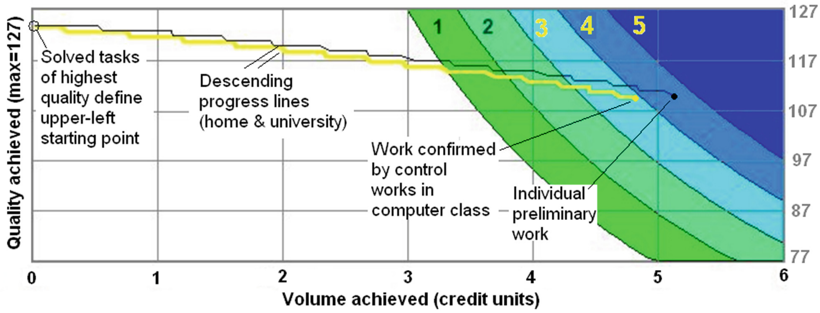

Fig. 2. Volume-quality plane of student progress. Grade areas from “1” to “5” are shown by colored zones. The right end point of yellow progress line shows the currently achieved grade by tasks confirmed in control work mode in university classroom. The black line characterizes the home made tasks that are not yet confirmed in control work mode in university.

In 2017–2018 was started development of 3rd generation of ISC system [7, 8] by introducing more reliable php-language based programming, a compact one main page design, immediate ubiquitous switching between Estonian and English presentations, better compatibility with mobile phones and tablets, and readiness for remote laboratories. In May 2020, the quality sign of Estonian Information Technology Foundation for Education HITSA was awarded to the ISC-system [10]. The convenient compact design of main working field of 3rd generation ISC-system is shown in Fig. 3 below.

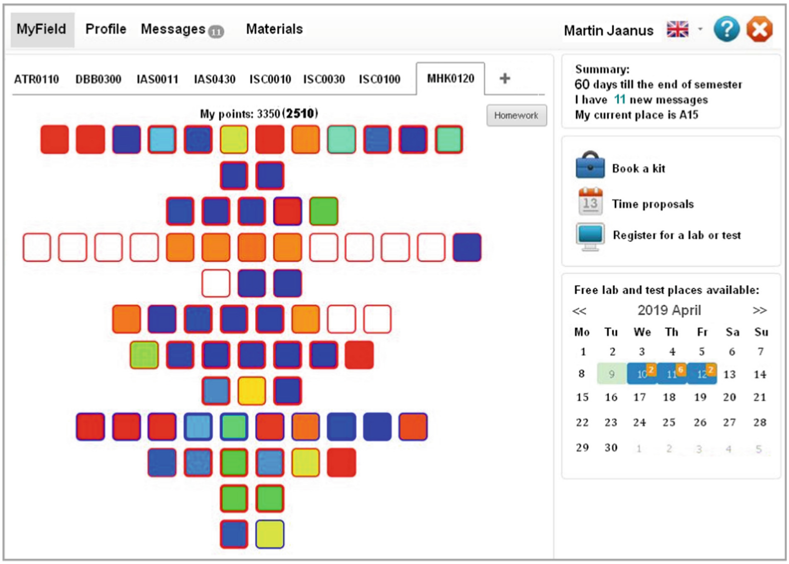

Fig. 3. The one main working screen design of ISC-system [7, 8]. Colored boxes show the state of competences (or tasks) associated with the course. White indicates yet unresolved competences/tasks, light green marks exceeding of the threshold (77) and dark blue reaching an excellent level of ability (118–127). Line above the colored boxes show the available other courses. Right part of screen serves for ordering of Home Lab Kits, for reservation of labs (i.e. training lessons in classroom) and reservation of test places (i.e. control work hours in classroom to confirm the tasks made at home). The language switch button is on the top right part of screen. Button "Homework" serves for uploading of the optional homework files in pdf-format. Teachers can switch between modes "teacher", "design of new tasks" and "testing as student".

Up to now system has been used by more than 5400 students who have obtained over 5300 grades from over 40 courses in between 2003 and 2020. Some important moments of ISC-system development timeline are summarized in Table 1.

By now, ISC-system has been used by 5 institutions in 2 universities:

1) Tallinn University of Technology;
2) Tallinn College of Tallinn University of Technology;
3) Virumaa College of Tallinn University of Technology;
4) Tallinn University;
5) Haapsalu College of Tallinn University.

Table 1. ISC-system development timeline facts.

Characteristics	Years	Comments	Generation
Instant feedback and database	2003 spring	Online answer evaluation and systematic functioning via database introduced	1
Student's memory model	2007, 2010	Exponential model 2007 – 2010, power law model from 2010 [1, 2]	
Home laboratory kits HLKs	2005, 2007	Mobility feature realized, HLK version 1 in 2005, version 2 in 2007 [1]	
Competence based control	2010	Multiple atomic competences corresponding to every learning task	2
Self-decided grade	2010	Student decides grade accepting moment by achieved quantity and quality	
Value added mode	2015	Different individual starting levels of students considered [4]	
Distant laboratories	2017–2020	Remote use of permanent laboratories in university (under development)	3
Reprogramming and redesign	2017–2020	Reliable and compact one main page design, ENG/EST double language operation [7]	

3 Formulation of Key Features of ISC-System

In order to construct a methodology of assessment and development of innovative learning systems, it is reasonable to construct a list of main features that are expected from an advanced learning system.

Below in Tables 2 and 3 is proposed one possible formulation of key features of the ISC-system. Table 2 describes the 7 main key features with the comments and Table 3 adds the 9 secondary key features of ISC-system. First reason for this kind of decomposition is to give the reader the opportunity to compare with other similar systems. Another reasoning is preparation of the logical structure for introducing feature-based questions for user satisfaction surveys for the further improvement of the system.

Table 2. Decomposition of main key features of ISC-system.

No.	Short denotation	Explanation	Reasoning
1.	TBL/CBL	Task/competence based learning. Student must solve a great number of tasks to achieve wanted grade (see Figs. 2 and 3 above)	Solving of tasks stimulate engineering creativity
2.	IAF24/7	Immediate automatic feedback 24/7. (Exception is greater homeworks with report in pdf format)	Makes possible place-independent and all-time learning. High student satisfaction

(*continued*)

Table 2. (*continued*)

No.	Short denotation	Explanation	Reasoning
3.	FL2T	From lectures to tasks. Replacing passive lectures with solving of well-designed training tasks	Lectures are too passive form of learning, more effective is solving of tasks where lecture materials are needed
4.	HLK	Home Laboratory Kits	Courses with practical tasks become possible. Real mobility of learning introduced
5.	FlexCont	Flexible timeschedule of control works. Student decides itself when to reserve hours in classroom to confirm the tasks solved at home in control work mode	Teacher must not waste time on control works management. Control works occur through all semester. Teacher can use time for preparation of quality tasks
6.	NoEX	No traditional exam. Grade is formed on the basis of performed tasks (confirmed in classroom in control work mode)	Teacher must not waste time on management of exams and follow-up exams. However more training classes are needed in the end of semester
7.	Flexit	Flexible grade acceptance and course ending	Student can decide how much he/she is ready to work to obtain the wanted grade. Teacher is freed from subjective decisions

Table 3. List of secondary key features of ISC-system.

No.	Short denotation	Explanation	Reasoning
8.	2Lan	Full double (or multiple) language capability	Learning of international terms (nearly mandatory in IT field!). Accuracy of presentation of tasks. Increased number of involved students. Less need for parallel courses (economy!)
9.	RepBL	Repetition based learning. Task must be solved multiple times (5–10) with different data to achieve excellent ability level	Student must assure that the content of task is understood
10.	MeMod	Memory/forgetting model of student included	Estimate forgetting and compensate loss of knowledge by smart repetition of tasks
11.	LessLec	Smaller number of lectures planned. Lectures replaced by on-demand training lessons in computer class	Better learning of lecture materials via solving of tasks. Increased efficiency of time usage for teachers and students

(*continued*)

Table 3. (*continued*)

No.	Short denotation	Explanation	Reasoning
12.	MultiParT	Multiple output parameter tasks	More complex homework type tasks can be included Difficulty to guess correct answers by random trials without understanding the content
13.	VarDifT	Variable difficulty (and weight) of tasks. Teacher can compose tasks with difficulty from elementary level to complex homework type tasks	Freedom of course construction. Possibility to add homework tasks with automatic instant feedback
14.	SAoL	Situation Awareness of learning. Availability of detailed individual task- and competence based progress statistics	Students and teachers are aware about exact situation of the learning process. Necessary corrective actions can be planned
15.	OneScr	One main screen design	Ease of use. Short learning time
16.	RemoteL	Remote laboratories readiness	Sophisticated laboratory tasks with advanced equipment may be included

4 Assessment of ISC-System Performance Under Quarantine Conditions

As explained above, the learning process in ISC-system that uses HLKs for practical tasks has a considerable level of freedom in terms of both timing and location. Following the introduction of coronavirus quarantine conditions in Estonia on 12th of March 2020, most of the key functions of the ISC system listed in Tables 2 and 3 retained full functionality despite the cancelling of all group work in classrooms. Only the following few actions were partially affected:

1) Scheduled group training lessons in computer classes;
2) Control works in computer classes for several students at the same time to confirm the home work results;
3) Lending and collecting of home laboratory kits.

Below in Table 4 are commented only those 2 key features from Table 3 that were influenced by the coronavirus quarantine. The remaining 14 key features could be rated “full immunity”.

Table 4. Feature-based assessment of quarantine immunity capability of ISC-system.

No.	Short denotation of key feature	Immunity to quarantine	Comment
4.	HLK	Partial	Lending and collecting of home laboratory kits was possible only by individual agreements
5.	FlexCont	Partial	Control works in university computer classroom were suspended. Teacher was able to replace the missing information by individual contacts and the results achieved at home (black progress line in Fig. 2)

5 Study of Quarantine Influence on the Student Behavior by the Task Solution Statistics

The previous section provided the feature-based explanation of the reasons why the ISC system retained its core functioning capabilities under quarantine conditions that suspended all direct people contact based group work activities in university. Here, in order to demonstrate the SAoL (Situation Awareness of Learning) capability of ISC-system and to investigate the student behavior changes due to the quarantine, the detailed statistics of task solving is analyzed for 2 courses for spring semesters of years 2019 and 2020. Table 5 summarizes the student numbers for the involved courses.

Table 5. Student numbers for two courses of bachelor level involved in statistical study.

Year and semester	Courses		
	ATR0110 Analogue and Digital Engineering	ISC0100 Cyber-Electronics	Summary
2019 spring	76	50	126
2020 spring	53	73	126

Table 6 presents the numbers of theoretical (Q) and practical (L) tasks included in the present statistical analysis. The statistical extract in both years corresponds to the period from semester beginning on February 1st until May 28th that is a date corresponding to approximately 1 week after the nominal end of the auditory work in spring semester under normal conditions. The practical tasks were performed either at home or in university with Home Lab Kits. It should be emphasized that summary number of tasks equals 216556 that makes this kind of statistical analysis practically impossible for teachers using traditional non-computerized learning technologies.

Table 6. Total numbers of theoretical (Q) and practical (L) task solving attempts.

Year and semester*	Courses						
	ATR0110		ISC0100		Summary		
	Q	L	Q	L	Q	L	Q + L
2019 spring	46516	3137	52337	3537	98853	6674	105527
2020 spring	35369	1650	70067	3943	105436	5593	111029

* - Time span is from February 1st until May 28th in both years

Table 7 summarizes the workloads in a more concise form, where the average numbers of task solving attempts per student are presented.

Table 7. Average numbers of solved theoretical (Q) and practical (L) tasks per one student.

Year and semester*	Courses								
	ATR0110**			ISC0100			Average		
	Q	L	L/Q	Q	L	L/Q	Q	L	L/Q
2019 spring	612	41.3	0.067	1047	70.7	0.068	785	53	0.067
2020 spring	667	31.1	0.047	960	54	0.056	837	44.4	0.053

* - Time span is from February 1st until May 28th in both years
** - Number of tasks smaller than for ISC0100 due to 3 mandatory homeworks with high weight

Comparison of student activity in two consecutive years 2019 and 2020 is presented in Fig. 4. One can immediately see that coronavirus quarantine in 2020 changed drastically the student behavior. Since most of traditional courses in university faced serious problems after March 13th and could not offer for students learning tasks, the students of ATR0110 and ISC9100 courses who used the ISC-system started to perform the theoretical and practical tasks with 4-fold activity. It should be emphasized that solving of the practical experiments with Home Lab Kits continued even with higher activity than solving of theoretical tasks. At the same time when ISC-system demonstrated in April and May nearly perfect functioning capability, many other courses in university discussed postponing of exams and laboratory works to the fall semester.

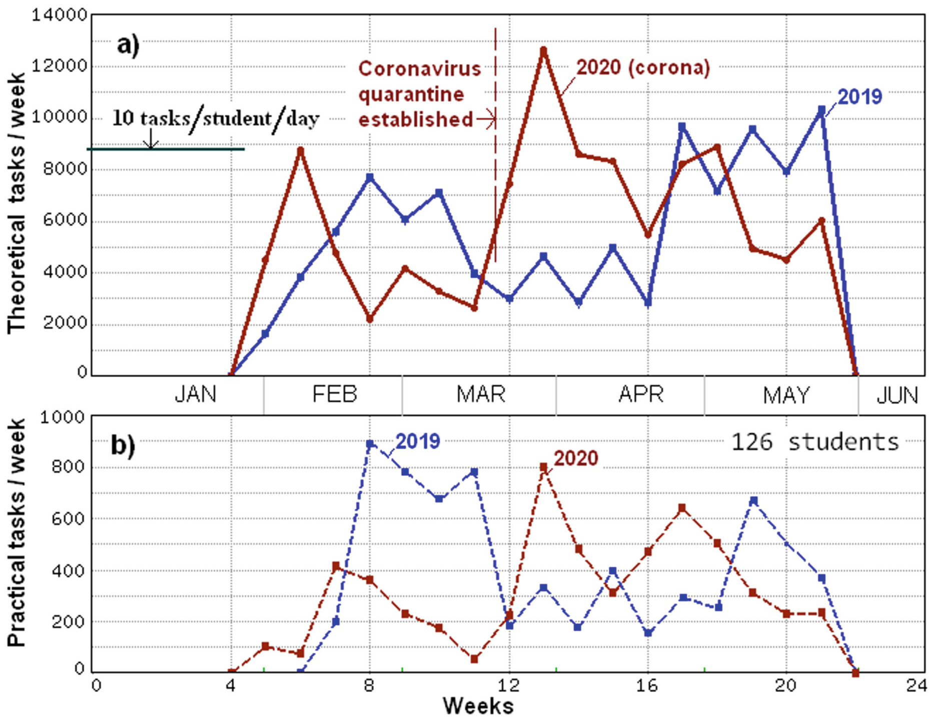

Fig. 4. The week-based comparison of student activity through the spring semesters in two years 2019 and 2020. Upper part a) shows solving of theoretical tasks, lower part b) shows solving of practical tasks with Home Lab Kit. As one can see, after the closing of university due to coronavirus quarantine in 2020, the activity of students exhibits abrupt 4-fold rise. This is clear evidence that other traditional courses in university faced serious problems and could not offer for students learning tasks while ISC-system was nearly immune to forced quarantine conditions. As a result, the students could finish the activities in May earlier than in previous "normal year 2019. This, in turn, demonstrates the benefit of time schedule planning freedom feature of ISC-system. The 2-week period of activity oscillations in year 2019 is caused by the 2-week period in availability of classrooms in this year.

Next, in Fig. 5 is compared the daily activity of students for two consecutive years 2019 and 2020. As one can see, the coronavirus quarantine is shifting the student activity to evening and night hours. Curves reveal also the fact that in year 2019 the students liked to solve the theoretical and especially practical tasks in university classrooms.

Finally, Fig. 6 presents a more detailed comparison of the student daily activities change in year 2020 after establishment of coronavirus quarantine restrictions in university on March 13th of 2020. The results confirm the previous conclusions – shift of activity to evening and night hours and disappearance of 2-h period classroom usage peaks during quarantine.

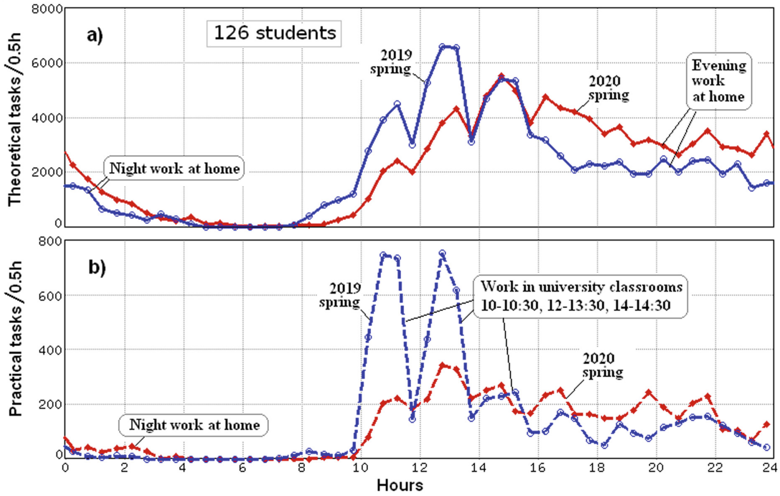

Fig. 5. Daily activity of students for two consecutive years 2019 and 2020. Upper part a) shows solving of theoretical tasks, lower part b) shows solving of practical tasks with Home Lab Kit. As one can see, the coronavirus quarantine in 2020 is shifting the student activity to evening and night hours. A that student activity with practical and theoretical tasks continues until 3AM and 4AM at night time, respectively. The curves of year 2019 are strongly influenced by 2-h period of availability of university classrooms and home activity is remarkably lower that in the case of year 2020.

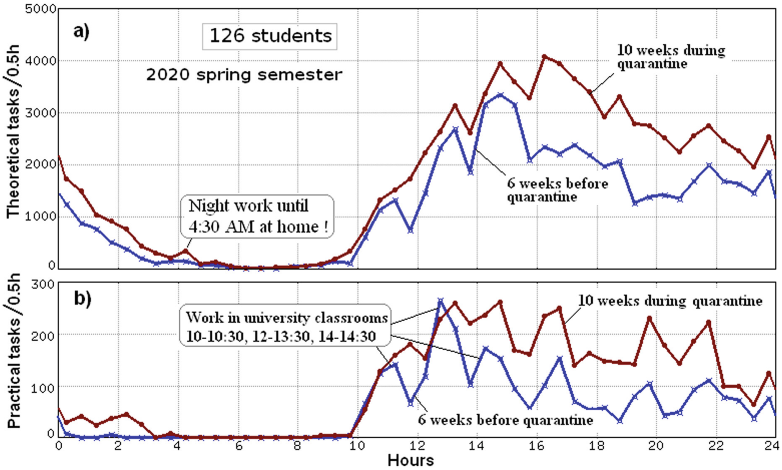

Fig. 6. Comparison of daily activity of students before and during coronavirus quarantine period for year 2020. Upper part a) shows solving of theoretical tasks, lower part b) shows solving of practical tasks with Home Lab Kit. As one can see, the quarantine is shifting the student activity to homework evening and night hours and the characteristic 2-h period caused by university classrooms availability disappears.

6 Conclusion

The interruption of all contact group work in universities due to coronavirus quarantine in the middle of the spring semester of 2020 posed serious problems for teachers and courses who used traditional approaches to organization of laboratory works, control tests and examinations. In contrast to this, the mobile task-based learning ISC-system developed in Tallinn University of Technology with implemented innovative ideas of flexible timeschedule planning, replacement of exams with continuous task solving and realizing of practical works with mobile laboratory kits, faced no noticeable difficulties due to switching to forced distant learning.

In the present paper we:

- Explained the development timeline and construction logic of the mobile task-based ISC-system;
- Offered a classification of innovative key features of ISC-system;
- Provided an assessment of immunity to quarantine conditions of ISC-system key features;
- Performed a study of the student behavior changes due to the quarantine restrictions on the basis of more than 216,000 task-solving records from years 2019 and 2020.

The results of the statistical analysis show up to 4-fold increase in student activity in April 2020, which can be explained by the low ability of other study courses to switch to distance learning. Another interesting result is the desire of students to work late at night even until 4 o'clock.

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Embedded System Learning Platform for Developing Economies

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Abstract. The continual research of electronic embedded system platforms for teaching and learning is of paramount importance. This is to increase the impact on a universities' ability to lead in technological advancement with goals to enhance innovation and accelerate the concept-to-deployment process. Technological progress in the fields of electronics, wireless communication, cognitive computing, and robotics has caused almost everything which connects to electricity to have a small processor and sensor embedded with itself [1]. Cognitive or Intelligent embedded systems are the 'core' of trends such as: reduced energy consumption, deep learning applications, improved security for embedded devices, cloud connectivity and mesh networking, and visualization tools with real time data.

This paper is aimed at stimulating design and innovation in electronics education through the rapid prototyping of configurable embedded systems. It also covers remote access functionality is also shown using cloud services. Divided into two parts, this paper gives design examples for both an elevator controller and a Data Acquisition (DAQ) system design. Focus was on the Programmable System on Chip (PSoC) 6 based kit, PSoC Creator software, and Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW) as rapid prototyping and learning platforms for digital and analog system designs. The Universal Digital Block (UDB) editor in PSoC Creator software was used to configure PSoC chip digital blocks and design a Finite State Machine (FSM) based elevator controller, which acquired digital signals and gave corresponding output. LabVIEW was used as a signal analysis tool and was also used to send results for online access and display. The PSoC and LabVIEW ecosystems are utilized here to bring an innovative paradigm into the embedded system design. These two platforms, especially combined with the virtual instrumentation concept, offer configurability and monetary value. This paper shows that the use of these ecosystems for the purpose of electronics education can accelerate learning and bridge the gaps within the online environments that students and universities find increasingly necessary.

Keywords: AFE · FPGA · FSM · LabVIEW · PSOC · UDB · Verilog

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1 Introduction

Networked embedded systems are an essential part of the electronics field and can be divided into analog and digital. This paper explains the implementation of a configurable mixed-signal system to stimulate project-based learning and remote laboratories.

The PSoC 6 platform is a mixed-signal configurable embedded platform; hence, it fits well for this purpose as it includes a variety of components like AD/DA converters, DMA controllers, logic elements, flip-flops, and lookup tables, which all diversify learning. The structure of this paper introduces the digital design and then goes on to discuss the data acquisition system. The growing importance of digital electronics systems design makes this an essential part of electronics. Digital systems have become less hardware-based and now are comprised mostly of microprocessors, firmware, and software [2].

This paper seeks to close the gap between discrete logic gates implementation and the advanced Field Programmable Gate Arrays (FPGA) implementations. The need to pursue this subject was confirmed in a survey conducted with Electronic Engineering graduates.

This shortcoming has resulted in numerous digital electronics-based laboratory designs ending at gate level in the lab. The PSoC comes as an intermediate method between these two extremes. The design method discussed in this paper works as a jumpstart to the new student as it does not require deep knowledge about digital systems. It encourages the implement-as-you-learn concept. An FSM-based elevator controller design was implemented, with results displayed on PSoC 6 kit. A data acquisition system was also implemented, with the results displayed both on LabVIEW and online.

This project augurs well with the United Nations' 2030 Agenda for Sustainable Development. It also addresses primary innovation challenges for developing countries in an effort to develop capacity to learn, adopt and diffuse current and new knowledge and technologies to promote sustainable and inclusive development [3]. The global market for the embedded systems industry was valued at $68.9 billion in 2017 and is expected to rise to $105.7 billion by the end of 2025 [4]. Knowing this, it is imperative that tertiary institutions tap into this market.

There exists a considerable body of work on the use of embedded platforms for online laboratories. One such work proposes an intelligent online interface supported by a dedicated hardware architecture that maps the circuits while they are being designed by the students. The hardware is based on low cost microcontrollers and port expanders. The system is capable of matching the current circuit with the target circuit in a web-based environment as well as finding the possible faults in the current circuit. The system has been shown to use a prototype board for digital electronics which can be scaled to implement bigger interfaces and more complex functions [5].

2 Digital System Design Experimental Steps

2.1 Programmable System on Chip (PSoC)

The PSoC 6 Bluetooth Low Energy (BLE) Prototyping Kit was used. This is a low-cost hardware platform that enables the design and debug of PSoC 6 MCUs. The kit features the EZ-BLE Creator module which is scalable and reconfigurable platform architecture. It combines reconfigurable and programmable digital and analog blocks with flexible automatic routing. The CYBLE-416045-02 also includes digital programmable logic, high performance Analog-to-Digital Conversion (ADC), low-power comparators, and standard communication and timing peripherals. Of particular interest to this project is the use of Universal Digital Blocks (UDB) for the rapid prototyping of the digital elevator controller.

2.2 Setting up a Universal Digital Block (UDB) Library and UDB Components

A UDB is a flexible, programmable digital block, shown in Fig. 1 inside a PSoC device, that is designed to realize synchronous state machines. The UDB Editor is a tool which allows the creation of UDB-based designs with just a very basic knowledge of digital logic or Verilog code. Using this graphical tool, one can drag, drop, and then configure hardware without having to write Verilog code [6]. The writing of Verilog code for digital designs is usually a turn off for many beginners. The UDB Editor takes care of many internal configuration details simply by specifying the parameters of the UDB blocks on the design canvas. The tool translates a design to Verilog in real time and shows how the UDB blocks translate to Verilog hardware description language (HDL).

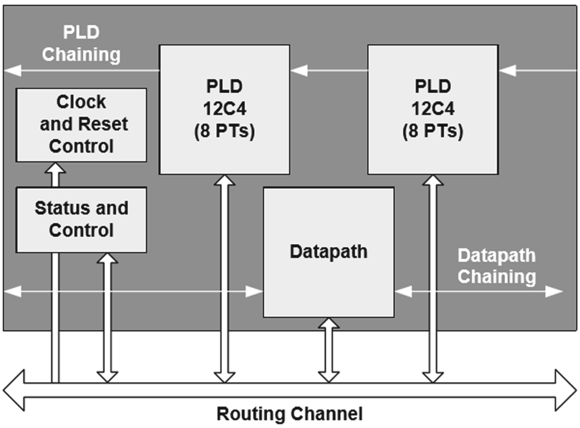

Fig. 1. Universal Digital Block

A library project was created in PSoC Creator software and was named a UDB library. The UDB document was then used to create a new UDB component, in this case an FSM. The component was targeted for PSoC 6 kit.

2.3 Finite State Machine Design

In the UDB library environment, state machine components were connected in three states and six transitions. In this case, the Moore type state machine design was used and gives outputs depending on the current state. The resultant state machine and state table are shown in Fig. 2 and Table 1, respectively.

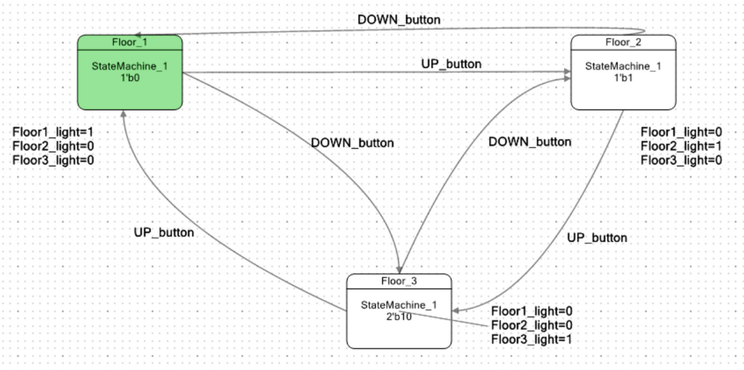

Fig. 2. The State Machine depicting the Moore Elevator

Table 1. The State Machine depicting the Moore Elevator

	Input	Next State	Output
Floor_1	UP_button	Floor_2	Floor1_light = 1 Floor2_light = 0 Floor3_light = 0
Floor_1	DOWN_button	Floor_1	Floor1_light = 1 Floor2_light = 0 Floor3_light = 0
Floor_2	UP_button	Floor_3	Floor1_light = 0 Floor2_light = 1 Floor3_light = 0
Floor_2	DOWN_button	Floor_1	Floor1_light = 0 Floor2_light = 1 Floor3_light = 0
Floor_3	UP_button	Floor_3	Floor1_light = 0 Floor2_light = 0 Floor3_light = 1
Floor_3	DOWN_button	Floor_2	Floor1_light = 0 Floor2_light = 0 Floor3_light = 1

Figure 2 and Table 1 show that the initial state is Floor_1, which is also the reset state. When an UP_button is pressed, the elevator moves from Floor_1 to Floor_2 and the arrival at Floor_2 is indicated by the corresponding LED. The routine is also followed for the transition from Floor_2 to Floor_3. Pressing the DOWN_button follows the same routine in the opposite direction.

2.4 UDB Component Generation

In the Universal Digital Block editor, the FSM was then generated into a symbol and added to the UDB library. The generated FSM symbol was then added to a new project in PSoC Creator software and the inputs and outputs were added to it, as shown in Fig. 3.

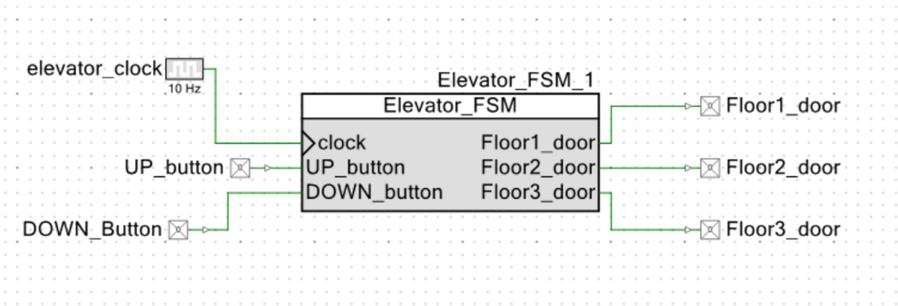

Fig. 3. Universal Digital Component for the FSM

In Fig. 3, the UP_Button and DOWN_Button digital inputs were given pin assignments in the PSoC Creator software which corresponded with the switches in the PSoC 6 kit. The elevator FSM block processes and acts on these signals according to the embedded FSM. The outputs gave the expected outcome as switches were being pressed. The elevator_clock was set at 10 Hz for prototyping purposes and so that the transitions and outputs would be observable. The main idea behind this is to utilize the PSoC Creator software and PSoC kits as tools for rapid digital system design and as a learning platform. The elevator serves as a good example because it has common functionality and it represents a full system level design. The FSM based elevator controller works as a digital input data acquisition system.

The FSM technique has been chosen because it serves as a foundation for complete digital system controller designs and implementations. A useful formalism for designing more complex digital circuits is that of the FSM, whereby the circuit's function is broken down into a collection of states and rules which determine when the system moves from one state to another state [7]. The FSM based design, as stated, is the entry point for a student to have a feel for real-life designs. At this stage, students can design controllers for systems like a vending machine, a subway entrance turnstile, a heating system, an automated subway system, a self-driving car system, and an elevator. While the FSM can implement any digital design algorithm, it becomes overcomplicated when dealing with data. It is therefore necessary to include the controller and data path in the digital system design because they are more efficient to process and memorize data under the machine's control. They optimize the sharing of duties between the FSM and an external architecture. For the sake of this paper, this technique has been avoided to circumvent a steep learning curve for the student at the foundational level.

2.5 Verilog Code Generation

After the configuration of the FSM in the UDB editor and the generation of a UDB library component, a Verilog code was also generated. This Verilog generation is one of the main advantages for students to use PSoC Creator software. The student can learn how Verilog represents their design and can then edit the code if they want to add some functionality that may not be addressed by the UDB editor. The initial goal of having a functional full digital system will have been achieved. Figure 4 displays a snippet of the generated elevator controller Verilog code which shows the declaration of floors as states and their associated transitions. This code can then be ported into any Field Programmable Gate Arrays (FPGA), if the student so wishes.

```
module Elevator_FSM (
    input wire clock,
    input wire UP_button,
    input wire DOWN_button,
    output wire Floor1_door,
    output wire Floor2_door,
    output wire Floor3_door;

/* =Assignment of Combinatorial Variables =
assign Floor1_door = (Floor1_light);
assign Floor2_door = (Floor2_light);
assign Floor3_door = (Floor3_light);

/*State Machine: StateMachine_1
always @ (posedge clock)
begin : Floor_1_state_logic
    case (StateMachine_1)
        Floor_1 :
        begin
            Floor1_light <= (1);
            Floor2_light <= (0);
            Floor3_light <= (0);
            if (( UP_button ) == 1'b1)
            begin
                StateMachine_1 <= Floor_2 ;
            end
            else if (( DOWN_button ) == 1'b1)
            begin
                StateMachine_1 <= Floor_3 ;
```

Fig. 4. Verilog partial code depiction

Students can import the Verilog code, generated in the PSoC Creator environment, into LabVIEW FPGA Virtual Instruments (VIs) using the Hardware Description Language (HDL) Interface Node in LabVIEW software. One can test the functionality of the HDL code using an HDL simulator. A shell of the testbench should be generated which includes clock and enable inputs. One must add code to the testbench shell to test the functionality [8].

3 Data Acquisition Experimental Steps

3.1 ADC and UART Configurations

In this experiment an external hand-touch signal (Vin) was inputted into the processor through an ordinary connecter wire. The input pin was configured as a high-impedance analog drive mode. The signal was fed into an Analog-to-Digital Converter (ADC) which then passed on the digital signal to a Universal Asynchronous Receiver-Transmitter (UART) for onward transmission to the LabVIEW environment and displayed on the virtual graphs. The signal was then displayed in real-time on an online platform. The PSoC Creator software was used to configure an ADC component. During this configuration, parameters such as channel type, input mode and range, interrupt limits, data format, and timing were adjusted. In the UART, data format, transmission speed, bit order, data width, parity, and baud rate were also adjusted. The ADC and UART schematic connection is shown in Fig. 5.

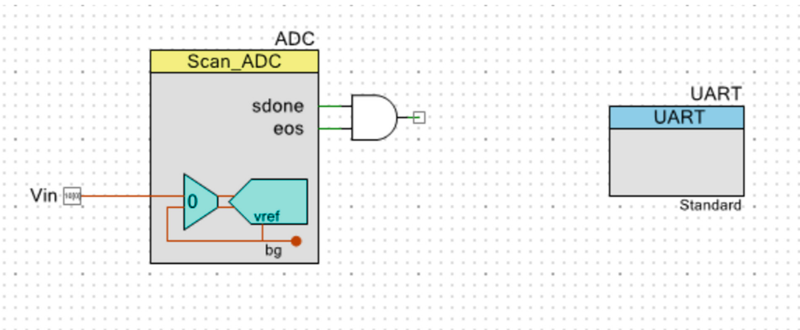

Fig. 5. Universal digital block

The drag-and-drop function is an advantage offered by the PSoC Creator software environment. To configure UART components in some FPGA environments, a long code has to be written. In PSoC Creator software, this is done by just double-clicking the component after dragging it from the library. Thus, PSoC is well suited for concept-to-deployment acceleration.

For the design, which uses multiple sensors, the PSoC Analog Coprocessor kit can be easily utilized. This simplifies the design of sensor-based systems by delivering a reconfigurable and scalable architecture that integrates programmable Analog Front Ends (AFE). The PSoC Analog Coprocessor kit consists of a signal processing engine (32-bit Arm® Cortex®-M0+) that can calibrate and tune the AFE [9]. The AFE interfaces to humidity, temperature, contact, motion, and ambient light detection sensors.

3.2 Interfacing PSoC 6 with LabVIEW

The PSoC 6 was interfaced with LabVIEW using the National Instruments (NI) implementation of the Virtual Instrument Software Architecture (VISA) Application Program Interface (API). The NI-VISA API provides a programming interface to control Ethernet/LXI (LAN-based eXtensions for Instrumentation), GPIB (General Purpose Interface Bus), USB (Universal Serial Bus), PXI (Peripheral Component Interconnect), VXI (Versa Module Eurocard eXtensions for Instrumentation), and serial instruments in NI application development environments like LabVIEW. NI-VISA is recommended because it is interface independent, has platform portability and is easy to use. An NI-VISA communication to the PSoC 6 was performed by opening a VISA session.

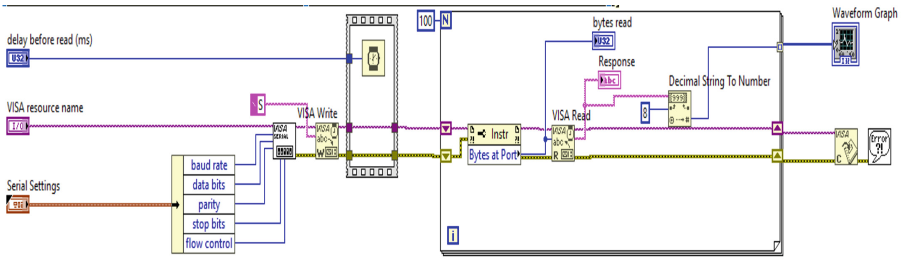

Fig. 6. The LabVIEW block diagram used for acquisition, process and display

Figure 6 shows how LabVIEW was used to process and display signals which have been acquired from an external finger-touch signal detection. The use of software-based processing tools allows for the designer to experiment with different functionalities until the desired result is achieved. LabVIEW offers numerous examples which students may customize according to their requirements. This, in turn, accelerates the design process (Fig. 7).

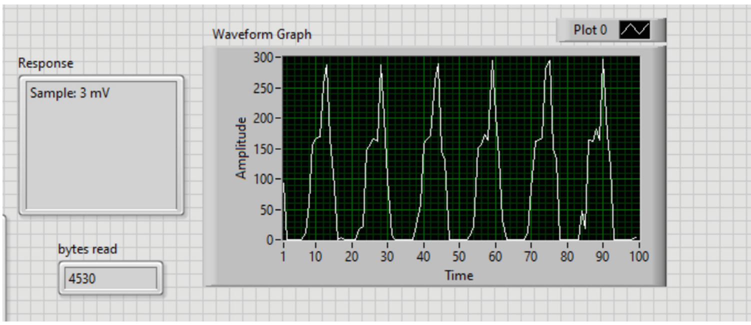

Fig. 7. LabVIEW graphical signal display

3.3 Online Access

Once the results are analyzed and displayed in LabVIEW they can be accessed online through the internet. One of the platforms for online access is ThingSpeak™, an Internet of Things (IoT) analytics platform service that allows one to aggregate, visualize, and analyze live data streams in the cloud [10]. ThingSpeak provides instant visualizations of data posted by devices to the ThingSpeak webpage. It is often used for prototyping and proof of concept for IoT systems that require analytics. Figure 8 shows a LabVIEW block function which was used to publish data on a ThingSpeak webpage and could be accessed publicly. The Uniform Resource Locator (URL) is split and concatenated. An Application Programming Interface key (API key) is then included in the URL. Figure 9 is the sample result displayed on the ThingSpeak webpage. Data can also be sent in the reverse from the cloud to the computer.

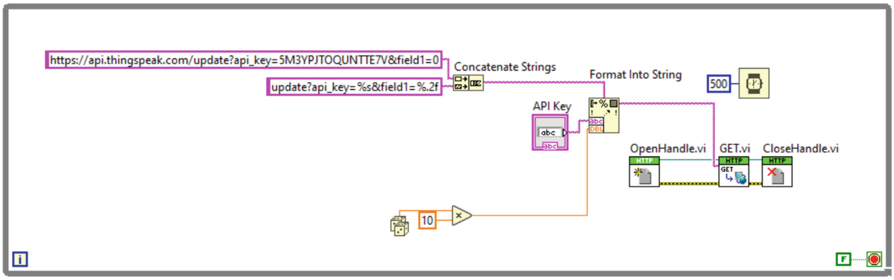

Fig. 8. LabVIEW block diagram for website publishing

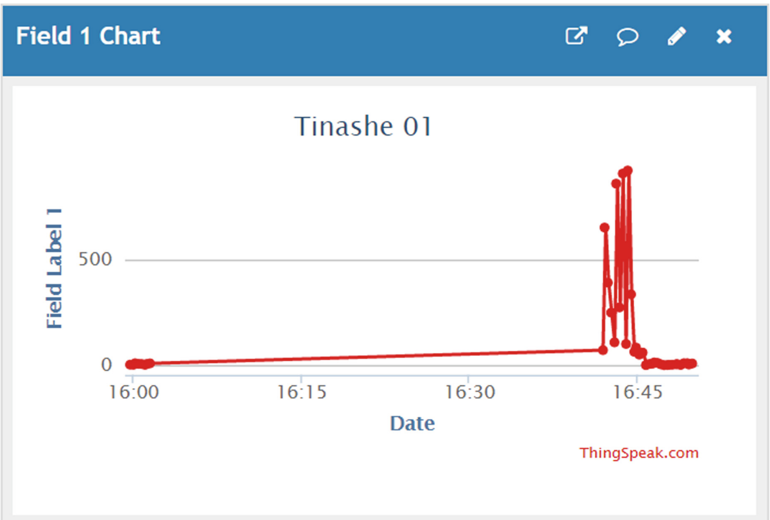

Fig. 9. Waveform displayed on the ThingSpeak webpage

4 Conclusion

This paper has shown that PSoC and LabVIEW ecosystems can be used for rapid prototyping of embedded system designs. PSoC kits can also be used to bridge the gap between discrete logic gates laboratory and the advanced FPGA implementations. Although the UDB editor lacks versatility compared to coding with Verilog or using FSMs with datapaths, it provides a soft landing and flattens the learning curve for students. Students may access these advanced learning tools upon grasping the fundamental concepts. The concept of Virtual Instrumentation is critical to teaching and learning of electronic embedded systems. The combination of PSoC and LabVIEW ecosystems provides an unmatched synergy for embedded system design. A design can be initiated on PSoC Creator and the signals acquired through LabVIEW and eventually displayed online. The use of PSoC environments for design, in general, needs to be tied to a cloud system so that students can access and perform experiments online. Furthermore, a cloud management system should be implemented. The recent outbreak of COVID-19 has made online laboratories an unavoidable venture for learning institutions. PSoC and LabVIEW ecosystems are an excellent platform for learning fundamental and advanced digital, analog, and virtual instrumentation concepts.

Acknowledgements. We would like to express our great appreciation to NI Corporation for availing a free LabVIEW license. Our gratitude also goes to Cypress Semiconductor Corporation for providing us with a free PSoC 6 BLE Prototyping Board (CY8CPROTO-063-BLE), thus facilitating this study and making it possible. Their generosity and collaboration were greatly appreciated. Special mentioned to Jessica Lewis-Realtor for providing free proofreading and editing services.

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Improving the University – Industry Environment by Adopting the Remote Experiment as a Pedagogical Method

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Abstract. ***Context:*** The work shows the alignment of virtual environment to the needs of the industrial revolution of level 4.

Purpose or Goal: The work insists on the qualities that remote experiment offers for the global engineer creation and on the skills for hiring and rapid adaptation to the industry needs.

Approach: In the university environment the remote experiment plays a decisive role in facilitating e-learning development for specialties that cannot exist without an experimental-applying part. Remote experiment must to satisfy both the needs of evolution in education and those from the industry (i.e. globalization, digitalization, socio-economic world). It is noted the emergence of new skills namely: "Cognitive flexibility" and "Emotional intelligence". After us, the most important trend, derived from the application of remote experiment and its use is "acceptance of failure". Until recently, the failure was penalized with bad marks. Acceptance is defined as a succession of failures by whose gradual removal, the amount of accumulated knowledge increases. It was concluded that failure is an important part of the road to innovation and creativity.

Actual or Anticipated Outcomes: Technology progresses exponentially and the society linear. Over time, it can create a gap between technology and society. It was found from practice that the remote experiment is much more connected to the needs of industry than classical laboratories.

Conclusions/Recommendations: Remote experiments can create skills and competencies faster than those achieved through classical learning systems for immediate necessity in industry.

Keywords: University · Industry · Remote · Pedagogy · Harvesting

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1 Introduction

Apparently, the remote experiment has distinct roles in academia and industry environments. In the university environment, remote experiment plays a decisive role in facilitating the development of e-learning for specialties that cannot exist without an experimental-applicative part in the curriculum [1–3]. This is the didactic component of the remote experiment. In the industrial environment remote experiment is a monitoring and control tool for processes that take place within the same enterprise (for example monitoring energy consumption at the enterprise level) or for geographically separated enterprises (e.g. controlling the production of subsidiaries in relation to the orders of the parent enterprise). In research, the remote experiment has gradually gained an important position in that various users can share with each other the possibilities of investigation offered by extremely expensive equipment and devices, which can be purchased only through a commercial alliance that thus becomes a scientific alliance. There is therefore also a practical component of the remote experiment (Fig. 1).

Commentators of the technical, economic and social development evolutions say that the remote experiment contains the functions described above as a manifestation of the 4th Industrial Revolution [4, 5]. Remote experiment succeed to managed both the needs of evolution in education (by adding the virtual environment in learning) and those from industry in accordance with the requirements of driving forces acting globally: globalization, digitalization (with an exponential rate of change in comparison with the estimated linear rate), the horizontalization of the socio-economic world (which allowed the transfer of power towards to consumers and the end user, thus redrawing the hierarchies in the socio-economic world) and finally the mixing of technical, economic and social cultures (which allowed, as a result of easier access to software and tools, a stage in which users can become manufacturers) [6–8].

2 Remote Experiment and Hiring Graduates

The main role of engineering education is to increase the employment opportunities of graduates by stimulating skills and shortening the periods of adaptation to the needs and desires of the industry [9]. If a valid definition of employability is referred to, it can be said that it is: "…***a combination or a "set of achievements" of skills, knowledge, understanding and personal attributes that together make a graduate more likely to gain and remain in employment….***". Because in this material the attention is focused on remote experiment, which is part of the category of tools and methods of application training, an analysis of the evolution of skills that the industry requires for employment, (considering the opinion of the World Economic Forum-Geneva for 2016–2020 period) [19], is indicated in the Table 1. In Table 1 the skills were placed in hierarchical order, exactly to highlight the dynamics of their importance, in short periods of time (five years), and the pivots that are necessary to support this dynamic [10, 11].

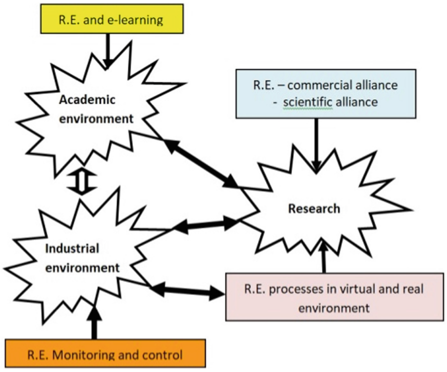


Fig. 1. Remote experiment roles in learning, research and industry

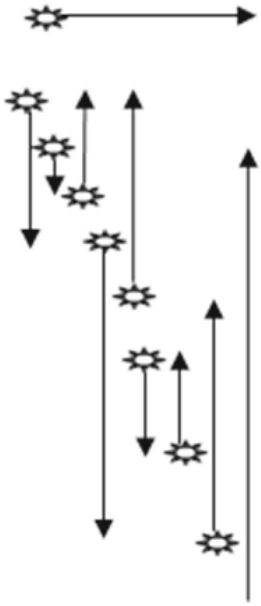
Analyzing Table 1, we notice first of all the increase of the importance of creativity (from position 10 to position 3), although it is not a skill that is developed within a curriculum, but is only facilitated by tangent, indirect methods [12–14]. Remote experiment is such a method, as evidenced by many studies of creativity.

It is also noticeable the emergence of new skills in these 5 years of evolution, namely: "*Cognitive flexibility*" and "*Emotional intelligence*". These are skills required by the exponential increase in the volume of knowledge in the field of engineering, which makes mandatory the ability to "navigate" in the "ocean" of existing knowledge and choose only those that are really needed to the technical evolution of the enterprise.

"*Cognitive flexibility*" and "*Emotional intelligence*" are skills that appear and consolidate throughout the use of the remote experiment. For the field of learning, these skills are the ones that contribute to the selection, from the network of distance experiments, on the most suitable ones and, in practice, the same skills allow the flexible selection of the most suitable "remote" solutions in terms of hardware and software, in line with the endowment of the enterprise and its development plans [15, 16].

The remark made by the World Economic Forum regarding the emergence of "*Cognitive flexibility*" skills has a lot to do with divergent thinking - the one that facilitates creativity. Education often uses the remote experiment as a transposition into the virtual environment of classical laboratory experiences, which incorporates into "remote experiment" convergent thinking, typical for classical knowledge transfer. The emergence of "*Cognitive flexibility*", as new skill, completes this picture with a new function - divergent thinking as stated earlier (Fig. 2).

Table 1. Evolution of skills in only 5 years. Changes of position and importance

Skills 2015	Place	Sense of evolution	Skills 2020	Place	Old /new
Complex problems solving	 1		Complex problems solving	1	Old
Coordinating with others	2		Critical thinking	2	Old
People Management	3		Creativity	3	Old
Critical thinking	4		People Management	4	Old
Negotiation	5		Coordinating with others	5	Old
Quality control	6 out		**Emotional intelligence**	6	**New**
Service orientation	7		Judgements and decision making	7	Old
Judgements and decision making	8		Service orientation	8	Old
Activelistening	9 out		Negotiation	9	Old
Creativity	10		**Cognitive flexibility**	10	**New**

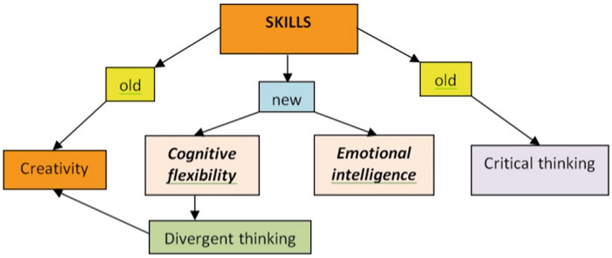


Fig. 2. Remote experiment increases the importance of creativity

3 Changes Caused by the Use of Remote Experiment in Learning

Globally, from the 10 skills presented in Table 1, the remote experiment is directly involved in: "*Complex Problem Solving*", "*Critical Thinking*", "*Creativity*", "*Emotional Intelligence*", and "*Cognitive Flexibility*", i.e. in a half. If we take into account the fact that the remote experiment, in addition to the directly transmitted knowledge, also contains a significant amount of "*embedded knowledge*", (i.e. the knowledge that the remote experiment creator has used for the construction of the experiment, without ask for their learning) can be said that remote experiment is an important tool to create those skills that support employability.

Engineering education must take into account the permanent dynamics of the skills that the labor market requires. As a result, more and more new trends have emerged in the pedagogical approach to engineering education. According to us, the most important trend, coming from the application and use of remote experiment as a learning method, is "*acceptance of failure*". The approach of the experiments using convergent thinking ensures the achievement of the expected end by the restrictions that eliminate the possible variants (apart from the accumulation of the minimum necessary knowledge). Failure is excluded even from the design of the experiment being possible only handling and setting errors. With the creation of remote experiment networks, users have several variants of experiment for the same end goal and it is possible to choose a variant that at some point, due to lack of necessary knowledge support, lead to failure. Until recently, failure was penalized with bad grades. More recently, the path to success starts to be defined as a succession of failures, through the gradual removal of which, the amount of gained knowledge increases and have been perfected, in a same time, a series of skills. It was concluded that failure is an important part of the road to innovation and creativity and that education must introduce and accept failure as a way of learning. As a result, the problem-based-learning system, which until now was designed in the system of convergent thinking (elimination of failure by successive constraints) must be designed based on real-world events. So, accepting of failure as a node, as a bifurcation, becomes the road towards the desired solution. As the remote experiment in the virtual environment comprises, for the same purpose, experiments with different hardware and software supports, it becomes an important tool in supporting the possible scenarios (divergent thinking) for the same purpose.

What else does the remote experiment add to the above? First of all, the ability to communicate and working in a team. The virtual environment offers this possibility of communication between people situated in different geographical places and coming from different cultural backgrounds. It also allows the formation of ad hoc teams that, through communication and collaboration, focus on solving problems of common interest. Each team will put in window their own knowledge and experience (explicit knowledge) and coming out from this collaboration with new experiences and new systems of thinking (tacit knowledge) (Fig. 3).

Is the phenomenon described above important? Is forced the consideration of the remote experiment as an important tool in modernizing curricula? We believe that not and we say, at the same time, that the importance of remote experiment will increase. The emergence of IoT only multiplies the principles of the remote experiment at the level of each object desired to be controlled. The emergence of the IoT concept is based on many of the principles of remote experiment and the future development of remote experiment will not be possible without taking into account IoT.

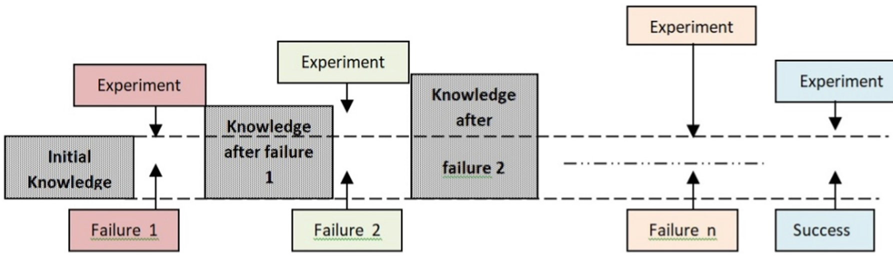


Fig. 3. The evolution of knowledge when the failure is accepted

Is the phenomenon described above important? Is forced the consideration of the remote experiment as an important tool in modernizing curricula? We believe that not and we say, at the same time, that the importance of remote experiment will increase. The emergence of IoT only multiplies the principles of the remote experiment at the level of each object desired to be controlled [17, 18]. The emergence of the IoT concept is based on many of the principles of remote experiment and the future development of remote experiment will not be possible without taking into account IoT.

4 Global Engineer and the Remote Experiment

This notion of global engineering was shaped by the emergence of the virtual work environment that broke the limitations of space and time and created an online workspace that facilitates communication between universities and students, universities and industry, students and industry. In addition, due to this virtual environment, the number of those who can be involved in solving real world problems has increased exponentially so that solutions have appeared faster and have been validated by a huge number of critical analysts.

This virtual engineering environment adds to the two pivots, without which real world problems cannot be addressed, namely the technical pivot and the professional pivot, three new pivots that, until now, were involved in solving problems only at the individual level, namely: the pivot of *interpersonal relationships*, the pivot of *personal qualiti*es and the pivot of *intercultural relations* (Fig. 4). Until the appearance of the virtual environment, *interpersonal relationships* revolved around the engineer who took on the approach of a real-world problem. Obviously, in this case, the circle of interpersonal support was limited. With the appearance of the virtual environment there is registered an evolution in two directions: - a classic one, of interpersonal relationships now established on a global scale and based on the same common interests in solving the problem and - an atypical one, determined by the existence of teams formed anywhere in the world, which have communicated some results obtained regarding the approached problem, teams that can be contacted and attracted. So there is a leap from teamwork in the classic sense to working in support teams formed not at the initiative of the person(s) who assumed the solution of a problem but formed by the problem itself and randomly distributed throughout the world. Thus, it can be said that teamwork gains new values: from the team formed on the criteria, subjectively determined by the leader of the first nucleus formed around a real world problem, to the team formed on the criterion of ad hoc association for a problem solving and randomly distributed in the geographical space. The main problem in the latter case is communication. Each team in the whole that can be formed around a problem has different stages of organization, different stages of the problem understanding and different stages of progress in solving. The strength of such a team must consist in the sharing of knowledge and stage achievements, because each party can have, in what it has already done, a seed necessary to increase the final solution. Well, the only appropriate way to put in common the stages achieved is the remote experiment. Each entity of the group in formation allows the access of the others to its own stage of solving, thus creating in the virtual environment a first project report. The combination of stages allows the realization of a starting point for the ad hoc team and the assumption of the development tasks generated by this first stage. Everything is done online using the facilities of the remote experiment and the virtual environment.

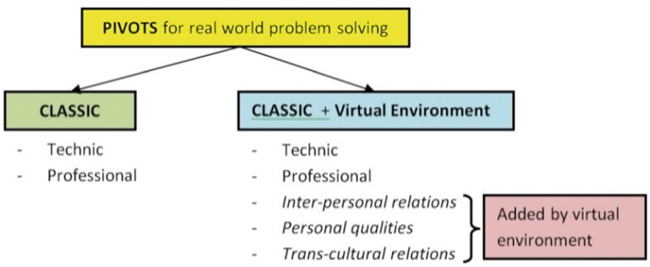


Fig. 4. New PIVOTS added in the real world problem solving by virtual environment

Once the inter-personal levers are used, the "*personal*" pivot enters in game because, all the solutions revealed through remote experiment, of the team formed ad hoc, must be analyzed critically and creatively by all members. They must to have an open mind to learning because the shared solutions certainly do not contain the same type of software or hardware and, the critical analysis mentioned above, cannot be done in the absence of adequate knowledge. The creative approach is the next step of the "*personal*" pivot and it must extract, from all the shared solutions, the one that can solve the real problem in a short time and with as little expense as possible.

In the case of "*inter-personal*" and "*personal*" pivots, the role played by the "*trans-cultural*" pivot is also important. The remote experiment plays the role of a "tester" who can assess the degree to which each cultural environment, from which the ad hoc teams come, has an interdisciplinary or multidisciplinary approach in training of its own specialists. Remote experiment also tests the mastery of English (in remote experiment English dominates), how the solutions, brought and shared, incorporated in remote experiment, contain a global perspective and, very importantly, the degree to which each experiment attracted and put in common, respond to the economic, social and political perspectives of the geographical area for which they work.

5 "Technical" and "Professional" Pivots and Remote Experiment

The "*technical*" and "*professional*" pivots are among the five that today define a global engineer (according to the World Economic Forum). Not every remote experiment is subject to the requirements of defining a global engineer. According to the source quoted above, a remote experiment (or more) that leads to the ad hoc establishment of multidisciplinary/interdisciplinary teams, must first reflect the fact that the phases of the life cycle of a product, i.e.: design - functional model - industrial model - testing of prototypes (models) - production - distribution and management were understanding and approaching. They are the constituent elements of the "*technical*" and "*professional*" pivots.

Of course, there are remote experiments that do not meet all the phases of the life cycle of a product mentioned above, but the phases that are taken into account in the formation of ad hoc teams must contain them or suggest them explicitly or in potentially manner.

A remote experiment talks a lot about the digital skills of their creators, about the level of use of information technology and about the way of documentation and information, compared to the existing literature.

A remote experiment also talks about the degree of understanding and mastery of science in general (its subsumption to the most modern trends) of the fundamental principles of engineering and about mastery of the mathematical foundations.

The "*professional*" pivot does not refer directly to the remote content of the experiment but is an analysis of the qualities of the team members who created it, a kind of critical analysis of CVs viewed from different angles than those currently used to analyze a CV. For example, for group members who have designed and conducted a remote experiment, an important professional quality is communication. Not only the one related to the transfer of technical and non-technical knowledge to users but also the one related to the ability to use several ways (written, handwriting, electronic, etc.) for these transfers. From the e analysis of the "*professional*" pivot must also be shown that the created remote experiment includes elements related to the user's ability to judge situations, his ability to make decisions and to assume risk management following decisions made.

The "*technical*" pivot (perhaps not given the happiest name) must show that the understanding of the remote experiment involves first mastering at medium level of the scientific and mathematical foundations of the field to which it belongs. Secondly, the remote experiment must call for an understanding (also of a medium level) of information technologies and rely on the latest scientific literature. Confirm that users have sufficient digital skills to maneuver the experiment remotely. Thirdly, the technical pivot must refer to one or more of the phases of the final product life cycle (design, prototype, testing, production, distribution channels, etc.) as well as to the impact of the final product on the team members, the sponsor, the client or the end-user, depending on the domain in which falls the remotely experiment.

6 An Example of Application of Above Principles

An example of University – Developer – Industry collaboration (promoted by the Center for Valorization and Transfer of Competences CVTC and IAOE for many years now) presented in this paper, it is connected the Romanian PN III contract no. 47/2018 with the title "Directions of technological Development and use of Advanced Nano-Composite materials - Oxidative Nano-Composite for Sensor applications˵. Sensors developed at THE NATIONAL INSTITUTE OF PHYSICS OF MATERIALS, have been studied at "Transylvania" University and will be implemented through close collaboration with industry (STEINEL Germany and Romania). A wireless automatic system will analyze the level of light in the rooms (using the sensor matrix developed in the project) and will control it according to the level of the natural lighting in the room. In this way it will ensure a minimal consumption and a stable - constant lighting at the workplace.

In the actual stage was developed the matrix of the oxidative Composite-Sensor (Fig. 5) and was investigated the responsivity to different spectral ranges of illuminations using one device with different LEDs connected on optical fiber (Fig. 6).

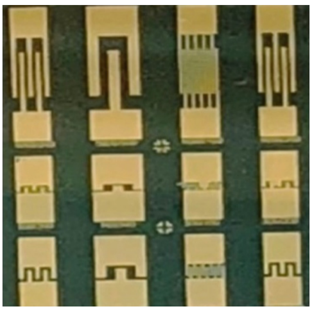


Fig. 5. Composite-Sensor

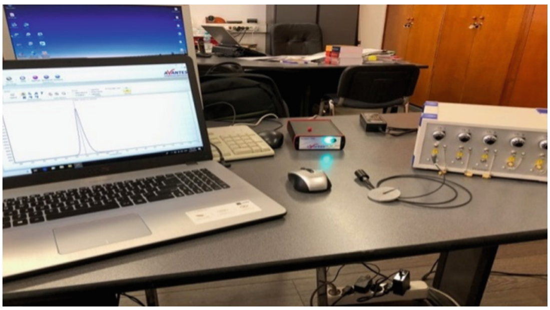


Fig. 6. Spectral Investigation of the LED multichannel source

In the next steps, selected structures, was investigate deeply on noise characteristics (knowing that the noise limited the Minim Signal Detection levels) and I-V characteristics function of the temperature (envisaging future broad range of applications in industrial sensing) presented in Fig. 7.

Now the next steps in the research will be connected with preparation the final shape of the sensor and prepare for the first industrial application in the field of Daylight Energy Harvesting. Till now we tested these situations:

- The Daylight Energy Harvesting must respond to this auxiliary sources of illumination and we tested this influences and the laboratory system respond and establish the desired 500 lx (fixed level of illumination)
- But we must consider also the influence of Daylight Energy Harvesting system on local fixed illumination (for example 1000 lx)
- In future we can replace the Webcam measurement system with a matrix of sensors which measure directly the illumination and control the light and in this situation we can use the same control for working places.

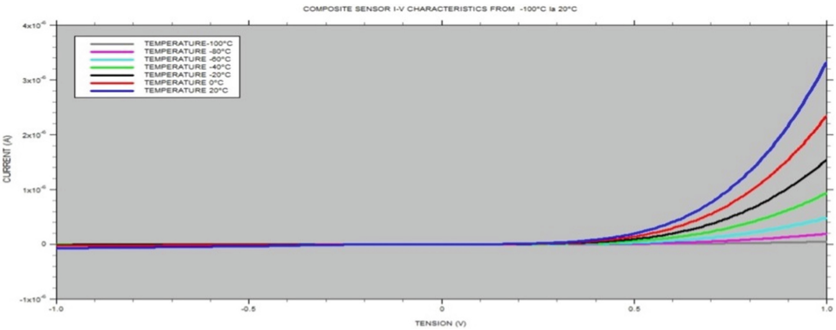


Fig. 7. Sensor I-V characteristics function of temperature in the range -100 to 20 degree Celsius

7 Conclusions

The above considerations were generated by the unanimously accepted finding that technology progresses exponentially and society linearly. As a result of these trends, over time, a gap can be created between technology and society that will be difficult to recover.

One of the ways chosen to approach the rhythms from the technical and social evolutions is the introduction of the experiment remote as a pedagogical method in education. This is due to the fact that the remote experiment, apart from the technical part it contains, cannot be applied without improving communication and teamwork. It has been found from practice that the remote experiment is much more connected to the needs of the industry than the classical laboratories of the current school and more connected to the creation of the IoT environment, the latest trend in monitoring and control in society. It was also found that remote experiment is most often related to inter-discipline and that it stimulates creativity because it offers multiple solutions for the same end goal, so it incorporates divergent thinking.

Remote experiment includes multiculturalism by breaking geographical boundaries and fits perfectly with the requirements of globalization. Remote experiment can overcome the lack of flexibility of current accreditation systems in education by creating independent courses (MOOCs) with content certified by the immediate requirements of the industry and the professional probity of the teachers who create them.

Remote experiments can create skills and competencies faster than those achieved by classical education systems when are applied on the narrow-field (which education systems do not address), but of immediate need such as: Big Data (advances analytics), Cyber Security, Artificial Intelligence (AI) or industrial Internet of Things (IoT).

The result of the adoption of the remote experiment in education will be, as a result of all the above considerations, a significant increase of the employment capacity of the graduates, on the background of the direct approach of the problems existed in the industry. Thus, we consider, the university-industry environment becomes much more dynamic and more adequate to the needs, being able to ensure both a thorough basic training and a quick response to the current needs of the industry, without neglecting the scientific foundations necessary to train the personality of a competent global engineer.

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Magnetic Measurements in Melotherapy

(Development a New Medical IoT Device)

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Abstract. The actual paper introduces a new magnetic measurement in MELOTHERPY based on the magnetic sensor MI-CB-1DH (developed by Aichi Micro Intelligent Corporation) having in view development of new Medical IoT device. Master students on Melotherpy from "Transilvania" University of Brasov – Romania, work in the Creativity Laboratory to develop new methods able to monitor (if possible) contactless the effect of music on human health. They interact with the professors – we discuss here about "affective education" – and try to learn: electronics, graphical programing, IoT development, and integrate the developed devices together with the classical measuring systems in activities of Melotherapy monitoring.

Keywords: Magnetic · Melotherapy · IoT · Medical IoT

1 Introduction

Many technologies are used in present for monitoring biomedical signals [1–3]. As we know Bio-Signals can be understood as any activity that measures the expression of a living organism. In case of "TRANSILVANIA" University of Brasov was of real interest to develop (together with the students from the Master of Melotherapy) different measuring technologies to detect the effect of music on body biomedical signals.

The heart and the brain communicate with each other thru 4 main channels: neurologically thru the nervous system, biochemically thru hormones and neurotransmitters, biophysically thru variations of the blood flow pressure and energetically thru the electromagnetic field [4].

The electric field of the heart is 60 times more powerful than the one of the brain. It can be measured anywhere on the surface of the body as an electrocardiogram (ECG). On the other hand, the magnetic field of the heart is 5000 times more powerful than the one of the brain. [4].

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To measure low magnetic fields, a technology called SQUID (Superconducting Quantum Interference Devices) is used now in medicine. Devices with several measuring channels for Magneto Cardio Grams (MCG) were developed thru improvement of the super-conducting magnetic sensors and cryogenic technology. The more used ones are developed by Quantum Design MPMS3 and by Cryogenic, like the model SX700 [5]. Both producers use superconducting magnets that allow measuring the magnetic field without direct contact with its source.

Because of the cryogenic technology involved, these devices are big ones, and they cannot be easily moved.

Using the SQUID technology, Keiji Tsukada, Hitoshi Sasabuchi and Toshio Mitsui have developed a noninvasive technique that analyzes the magnetic-physiological signals of the heart. The researchers used the MCG technique to diagnose the heart of an unborn child. MCG allows measurements to be performed without interfering with the amniotic fluid. Also, the interference with the magnetic field of mother's heart is low because the power of the magnetic field is inversely proportional with the squared distance between the sensor and the source. The power of the magnetic field measured in such cases is maximum 5 pT, which is about 10% of the power of the magnetic heart field of an adult.

To investigate this signals the research team had the idea to develop one new sensing technologies (Medical IoT) based on magnetic signals noncontact measurements, signals produced by human heart activities.

First idea was to develop and/or to use one sensible sensor but having in view to be a small one (battery powered) together with the afferent electronics and in the same time with the corresponding portability.

Preliminary test was done using the AICHI STEEL magnetic sensor [7, 8] and NI ELVIS National Instruments technology used in class activities with master students in the Medical Acoustics and Data Acquisition laboratories done inside the "Creativity Laboratory" of Center for Valorization and Transfer of Technologies" CVTC.

2 Magnetically Measured Bio-signals

For any enterprise, a key success factor is the quality of the product it delivers. In the education sector, this "product" is the delivery process itself, while in medicine; the customer – i.e. the student – actually takes part in the process as a "co-producer". These ideas were promoted in Creativity Laboratory of CVTC where the students work and do research in direct interaction with the university teachers based on model of "affective education".

In these laboratories was started the test of AICHI nT (nano-Tesla) sensors (MI-CB-1DH and new MI-CB1DJ) from Aichi Micro Intelligent Corporation https://www.aichi-mi.com. MI-CB-1DH series is a sensitive magnetic sensor which can detect magnetic field variations at extremely low level (noise fluctuations of around nano-tesla nT). This sensor consists of a 1-axial magnetic head (MI element) and an electric circuit to operate this MI element. By restricting the cut-off frequency on the low frequency side to 0.1 Hz, this model (sensor) cancels static magnetic fields such as geomagnetism and responds to only variable magnetic fields (see sensors properties in Table 1).

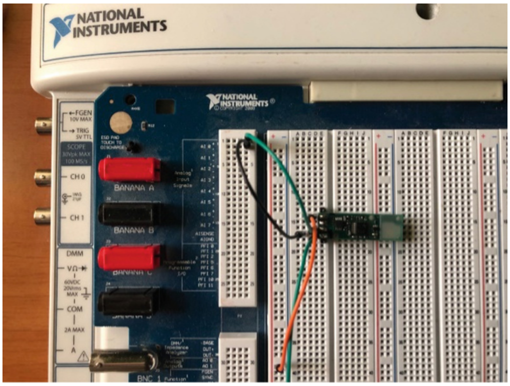
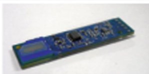


Fig. 1. AICHI nT sensor MI-CB-1DH firs NI ELVIS test

Students build on Meloteraphy Data Acquisition classes simple LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench) applications to visualize, filter and acquire the heart magnetically induced signals. This first system presented on NI ELVIS II systems (see Fig. 1) offers to our students the semi-quantitative images of sensor sensibility.

Table 1. Characteristics of AICHI nT sensor MI-CB-1DH and new MI-CB1DJ prototype (from Aichi Steel Corporation Catalog).

Model	MI-CB-1DH (Mass Production)	MI-CB-1DJ (Prototype)	Unit
Mechanical / Electric Characteristics			
Appearance			–
Size	11x35x4.6	13.5x55x4.6	mm
Axis	1	1	axis
Supply Voltage	+5	+15	V
Operation Temperature	-20 to 60	0 to 50	℃
Current Consumption	Single (S) : 14 Multi (M) : 8	Single (S) : 30 Multi (M) : 18	mA
Output Range	0.5 to 4.5	0.5 to 14.5	V
Magnetic characteristics			
Measurable Range	DC: +/- 40 AC: +/- 2	DC: +/- 20 AC: +/- 1	uT
Sensitivity	1	5	V/uT
Frequency Response	0.1 to 1k	0.1 to 10k	Hz(@-3dB)
Output Linearity	≦ 2	≦ 2	%FS
Noise Density (@1Hz)	30	10	$pT/Hz^{1/2}$

In the next stage the AICHI MI-CB-1DH sensor was tested inside the laboratory. To not have problems with the power network influences (220 V and 50 Hz), the selected solution to power the sensor was from a cellular phone backup well screened battery (see Fig. 2). It was also applied an active filter of 0–10 Hz using one Stanford Research Preamplifier/Filter SR 650 and the signal was visualized on Agilent DSO 6032A Oscilloscope. As it can be seen, the stability and low noise signal was obtained from the sensor.

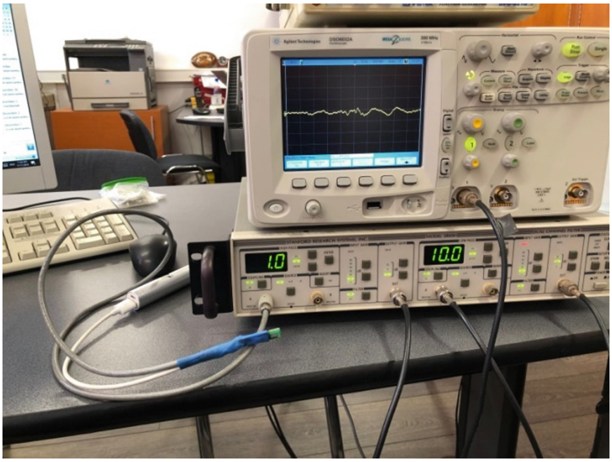


Fig. 2. Measurement setup: MI-CB-1DH Sensor, SR650 fitter and DSO 6032A Oscilloscope

After preliminary sensitivity test, the sensor was moved in the proximity of the heart and we recorded the sensor signal. It presented a good amplification level necessary for the digitalization and processing in future PC LabVIEW application, and also ready to be send (at the end of development) via Bluetooth (BT) to smart phones. In Fig. 3 we inserted one of the images with the measured human heart magnetic field fluctuations, captured and detected in this development. The heart detected frequency was correlated with the measured ones (in the same time) with Pulse Oximeter and Blood Pressure medical measuring devices.

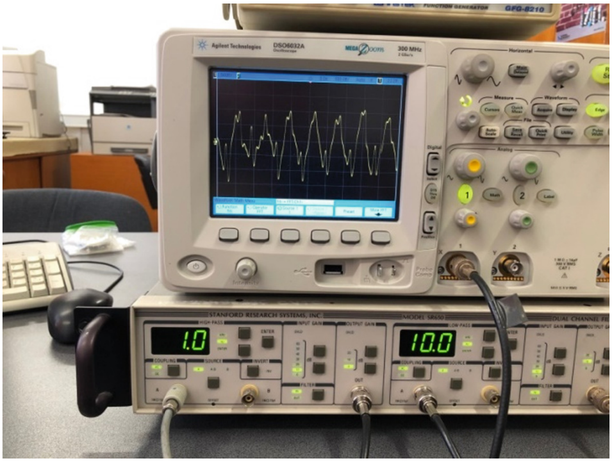


Fig. 3. Measured human heart magnetic field fluctuations

3 Preliminary Measurement in MELOTHERAPY

Ten melodies were selected (Table 2) and the team analyzed which of them produced more influences from the point of view of Melotherapy. The preliminary test was done measuring brain waves with the MindWave Mobile 2 system. In the next research steps the team would have to investigate how these results would be correlated with the measurement of the under development magnetic field sensing system [9].

Table 2. Selected Classic Songs with observations from the expertise and publications of the Melotherapy research team

Nr	Classic songs	Observations	WaveMind2 (Attentiveness/Meditation)
1	Domenico Scarlatti- Sonata in D minor K1 / L366, Performed by: Ivo Pogorelich	It enhances cognitive performance and the left hemisphere activity	53/46
2	Tomaso Albioni- Adagio for strings and organ in G minor, Performed by: Berliner Philharmonic	It slows the heart rate and lowers blood pressure	50/50
3	Johann Sebastian Bach- Prelude in C major BWV 846, Performed by: Lang Lang	It helps balance emotional state and reduces the level of anxiety	67/60
4	Gluck / Sgambati- Melody from Orpheus and Eurydice, Played by: Evgeny Kissin	It reduces negative emotional state and connects you with the divine	58/72

(*continued*)

Table 2. (*continued*)

Nr	Classic songs	Observations	WaveMind2 (Attentiveness/Meditation)
5	Wolfgang Amadeus Mozart- Lacrimosa, Performed by: Munich Philharmonic	It enhances synchronicity of the firing patterns of the right frontal and left temporoparietal areas of the brain	51/61
6	Beethoven- Sonata op. 27, no. 2, pp. I, in C minor, Performed by: Daniel Barenboim	It creates a melancholic mood and a sense of relief	47/68
7	Frederic Chopin- Nocturna in D flat major, op. 27, no. 2, Performed by: Radu Lupu	It uniquely activates several brain areas that were not active before	60/67
8	Frederic Chopin- Vals in A minor, op. Post., Played by: Grigory Sokolov	It gives to people stronger white matter connectivity between their auditory cortex	48/81
9	Franz Schubert- Gretchen at the Spinning Wheel, Played by: Yuja Wang	It targets the dopamine systems of the brain	68/74
10	Sergei Rachmaninov- Elegy in E flat minor, op. 3, no. 1, Played by: Vladimir Ashkenazy	It enables the listener to disengage from a distressing situation	64/53

4 Conclusions

This medical IoT sensor was well received by students at the Master on Melotherapy and they made preliminary research in the way to implement a new technology to monitor Bio-Medical signals and to record the modifications induced by music listening.

In the next step, the solution will implement Bluetooth BT monitoring on PC and smart phones.

Student developed systems and applications will be implemented deeper in their future DIPLOMA and DISERTATIONS work and will be used in the next years in the Data Acquisition laboratory for Meloteraphy.

Actual preliminary results look promising for contactless monitoring of biomedical signals and will be implemented in a small Bluetooth BT battery powered portable medical IoT device.

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Engineering Student Attitude Towards New Technologies Employed in Active Teaching

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Abstract. This work aims at evidencing the higher education students' perceptions regarding the use of some existing tools and technology for learning in education and how they use in their own learning, based on a systematic literature review. Considering studies in the Engineering education subject area, will allow understanding how students perceive and the importance that they give to a set of abilities such as communication, teamwork, leadership and management to achieve success in their academic life. This is an ongoing work, yet based on the examples gathered, all the environment developed based on technologies, generate positive students' reactions and supports diverse learning styles of students, comparatively to conventional methods, being engagement, level of interactivity and level of feedback between both students and teachers the most identified key aspects.

Keywords: Students attitude · Student engagement · Active teaching · Engineering education

1 Introduction

Society is changing and the way that a higher education degree can lead young people into a prominent professional career, provides a deeper understanding about the role of universities [1]. Powered by higher order thinking, character building, use of digital tools, enhancement of soft skills, the Internet of Things (IoT), the challenges in higher education are nowadays huge. The higher education is affected by the level of industrialization and the technological trends, being this evolution inevitable. However, the use of technology in education requires strategic and planning in order to avoid teacher/student frustration, economic losses and failed effort [2].

The classic higher education system is/was based on a classroom experience, where experts in a given field offer lectures for undergraduate students, within 18 to 22 years old, asking questions, giving instruction via textbooks, making assignments suggesting readings and conducting tests or exams. This mechanized education system has been replaced by the introduction of digital technologies and tools that allows a more dynamic teaching-learning experience. According to Nasir and Avunduk [3] significant advancements in the field of higher education over the years, and it continues to develop and change in response to the changing needs of the academic world.

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Roughly speaking, the timeline of technology in education can be described since the "stone age" till today (Fig. 1).

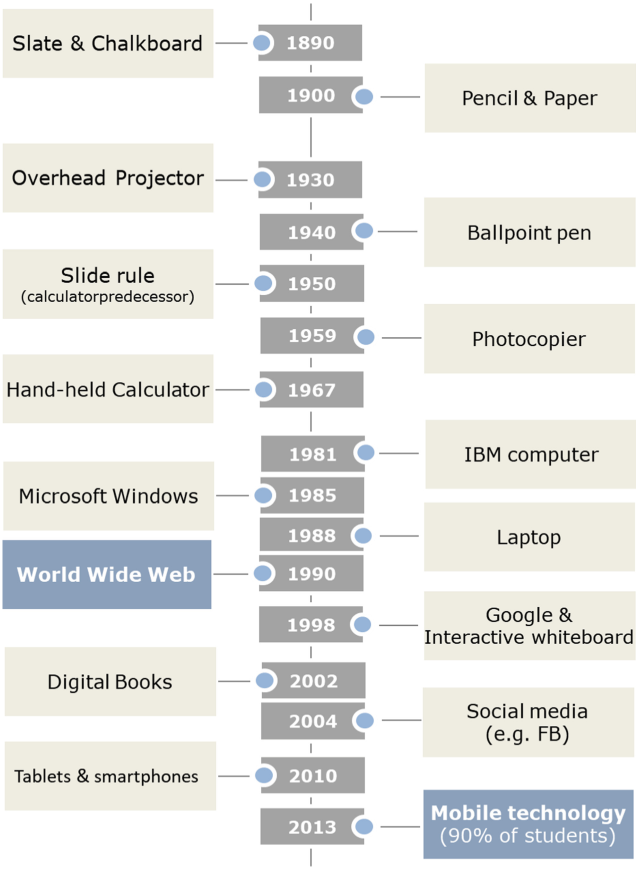

Fig. 1. Evolutionary perspective of used tools in education since 1980 to the present days.

By the end of nineteen century, through the twentieth century, some important innovations were developed in different context and used as pedagogical tools, namely, the first home computer (1981), the World Wide Web (1990), Google (1998), social media (2004) till the mobile phones (2013). Some of these innovations represented a great change in teaching-learning process. In mid 1990s, teaching based on web-based training allowed a great advance in communication. The integration of IT-based learning methods in lectures, seminars or workshops resulted in a combination of e-learning elements and face-to-face and promoted the so called "blended learning" [4]. The consequent significant step was achieved with the massive use of social media in larger groups and in virtual environments. Digital technologies diffuse and connect all aspects of student's daily life by melting all types of information [5]. Nowadays 90% of the students under the age of 18 have access to mobile technology.

Moreover, most students have grown up with high access to information available online and expect identical levels of knowledge in their educational environments as in their day-to-day lives. As a consequence, a bilateral relationship between the advancements in technology and its larger use can be established, which in turn leads to a faster digital evolution [6, 7]. Thus, the challenges of future teaching and learning must be turned into opportunities to improve the engagement of students in higher education.

There is an intrinsic relationship between the economic, social and educational growths. As we are experiencing a 4th industrial revolution, universities will need to work the resources of intelligence to prepare their students for their career aspirations [8]. To do so, several changes are required:

(1) Changes in organizational levels, by developing new concepts of interdisciplinary and cooperation at universities;
(2) Changes in teaching methods, by using digital tools and equipment for virtual learning experiences and artificial intelligence;
(3) Changes in learning through increased communication, 24/7 access to information, computing skills, etc.;
(4) Changes in accreditation and examination aiming for the positive effects on learning.

Also, it's important to understand the way that the teaching-learning process in higher education is perceived nowadays. Although controversial, students are been considered as the costumers of universities [9]. If higher education is becoming outlined as a service, its quality should meet the expectations of customers. Several aspects influence the student's expectations of higher education, such as scientific field, student's background, gender, age, academia environment or even career opportunities [1, 9, 10].

Concerning the Engineering students, it seems they worry about the importance of soft skills development in their curricula. It is unquestionable that a 21st-century engineer, in addition to his technical skills, must have a set of abilities such as communication, teamwork, leadership and management to achieve success in the workplace and to meet employers requirements [8, 11].

2 Scope and Research Question

The above mentioned corresponds to the motivation for this study. Thus, this paper describes the first endeavor to evidence how higher education students perceive the use of some existing tools and technology for learning in education and how they use in their own learning.

To start the study, the following research question (RQ) is formulated:

RQ: Are the teaching and learning methods used the one that students actually expected, ideally hoped for? Or, definitely they did not want?

This question is divide into three more specific questions helping to address the challenge:

SRQ1: What makes you a digital native? Is it enough to be born after 1980?
SRQ2: Which indicators were identified in studies where educational technology was used? Which indicators of student disengagement?
SRQ3: What are the learning scenarios, modes of delivery and educational technology tools employed in the studies?

The two sub research questions, SRQ2 and SRQ3, were defined based on the work of Bond et al. (2020) [7].

A systematic literature review (SLR) has been done for a better understanding of this topic. As stated by Snyder [12], SLR is a methodological tool that aims to identify empirical evidence that fits the pre-specified inclusion criteria to answer a particular research question or hypothesis. So, based on several studies published, general conclusions are provided, carried out systematically, deepening of the knowledge of the topic under study and also if possible, identify gaps in current research [13]. The work is still in the process of development corresponding to the first stage of a bigger research project.

3 Methodology

A SLR on documents or studies published dealing with students' attitudes towards new technologies namely the use of mobile phones in classroom was performed. The SLR methodology implemented was based on the following five steps: (1) planning the review and research question formulation, where the main problem is addressed as question (or hypotheses) in the most clear and unambiguous way as possible; (2) locating studies, based on different resources and where the inclusion and exclusion criteria are also established; (3) study selection and evaluations, based on the previous two steps and according to the type and amount to studies collected, a more refined in-depth assessment guides are defined transforming the study more clear helping the development of the next step; (4) analysis and synthesis; and finally (5) reporting the results achieved, identifying the strengths and weaknesses and making recommendations for future research [14].

The description of the SLR methodology followed are shown in Fig. 2.

Following the main objective defined, the online Scopus database was selected for documents search. This database was chosen for its functionality and multidisciplinary approach allowing significant contributions to other areas of Engineering education. Documents include papers in journals (articles), conference papers, review and book chapters.

Initially, the main keywords combination used was:

["student engagement"] AND [`technology"] AND "higher education"] AND ["learning"].

As a first approach, allowing a general perspective of developed works in this area, no filter was considered, i.e. "all fields" was chosen. As expected, a high number of documents were obtained (more than 13,000). These documents were of various type: from papers in international journals (64%), with the highest percentage, followed by conference paper (20%) to book (2%), review (3%). Thereafter, other filter used considering the Title, Abstract and Keywords (TITLE-ABS-KEY). The number of documents obtained reduced dramatically to 365, as illustrated in Fig. 3. Although with minor adjustments, the distribution of the various type of documents remained basically unchanged: papers in international journals (52%), with the highest percentage, followed by conference paper (43%), book chapter (10%), review (1%). These 365 documents correspond to the base documents to be included in the analysis.

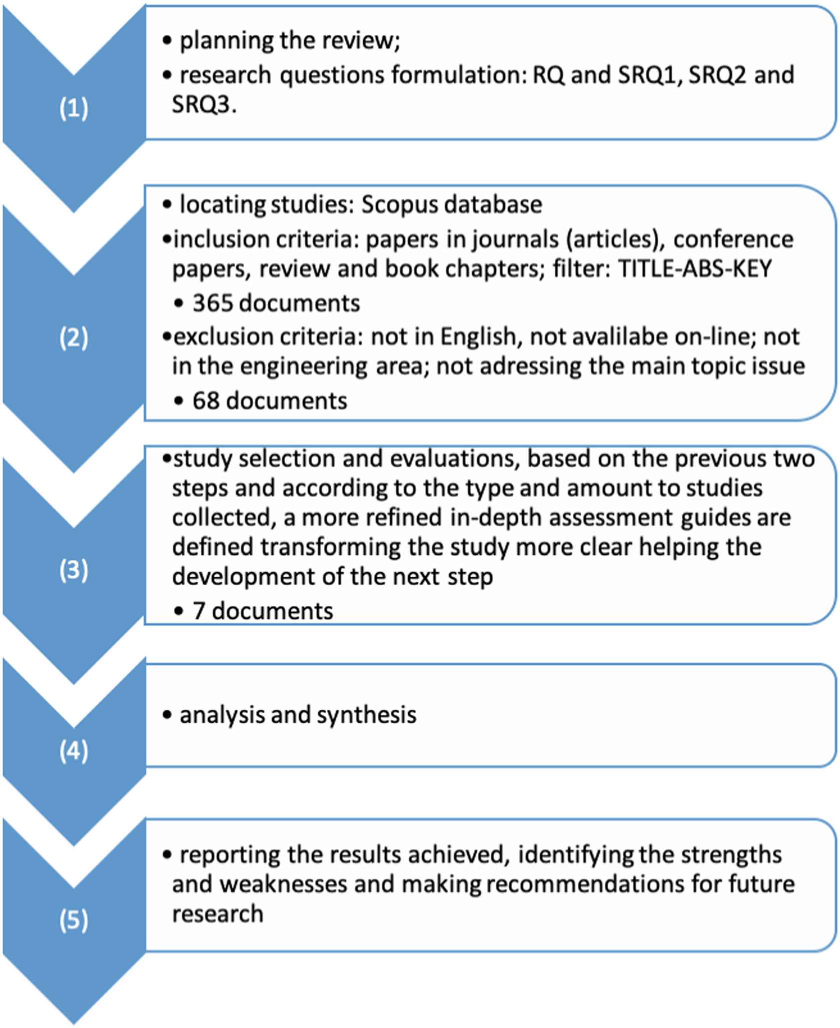

Fig. 2. SLR methodology based on [14].

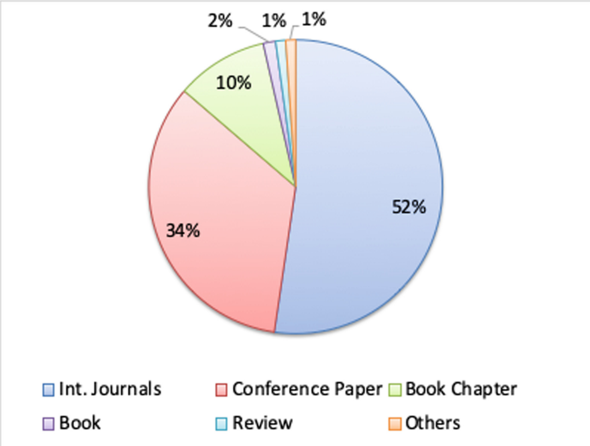

Fig. 3. Distribution of publications by type of document.

Regarding the reference period of time, no constraint was defined, to allow finding evidence and tendencies. The results are based on the search performed on May, 31, 2020. Only English-written documents were considered and available on-line.

The distribution of the total of publications over the years is shown in Fig. 4. Based on the main keywords combination and filters used, the first work published is an article published in the year 1998. In the year 2020, the value is lower since it corresponds to a year that still has not finished (present year). In general, one can say that from 2015 to the present day the percentage of publication accounted for more than half of the total of published works. This demonstrates an interest in the scientific communities concerns to understand how higher education students perceive the use of some existing tools and technology for learning in education and how they use in their own learning.

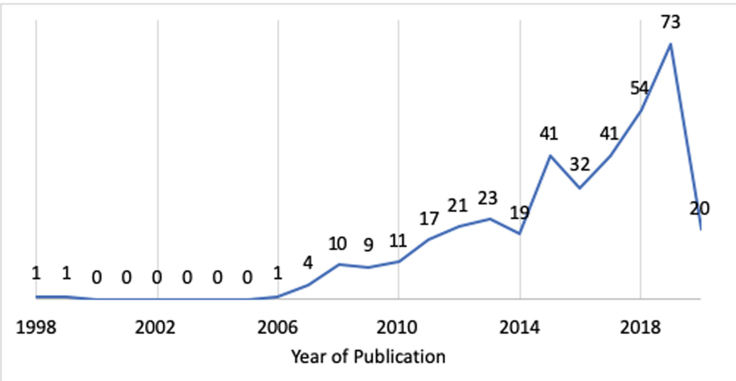

Fig. 4. Number of Publications distribution over the years.

In accordance with one of the exclusion criteria considered, works in the engineering field, 68 works (10% in Fig. 5) were selected based on the criteria defined in the Scopus database.

Then, on step 3 (Fig. 2), study selection and evaluations, the refinement was done after categorizing and classifying the selected documents by author, title or work published, year of publication, type of publication, and topic approached. The identification of the topic approached was done taking into account the keywords available and the codification developed by the authors. This codification process was done, in a first approach, based on the reading of abstract, methodology and conclusions of the selected documents. Both authors are meeting regularly to arrive a common interpretation minimizing subjectivity inherent to the analysis and interpretation. Due to time constraints, only 2020 and 2019 documents for this preliminary analysis, were considered resulting a total of 7 documents.

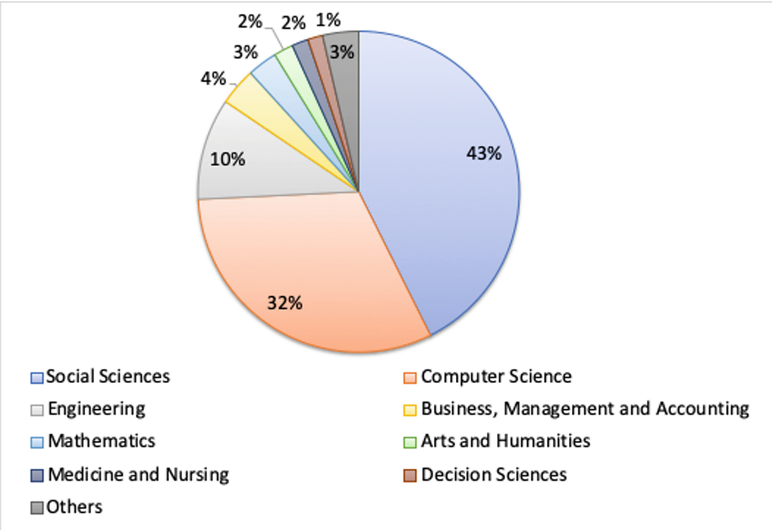

Fig. 5. Distribution of publications by subject area.

4 Preliminary Findings and Final Remarks

The results of the preliminary analysis of the SLR carried out are summarized in Table 1. For this preliminary analysis only considered documents from 2020 and 2019 were considered. The remaining documents will be analyzed subsequently in detail. So, steps 4 and 5 under development.

All the seven documents uses questionnaires to collect the quantitative and/or qualitative data concerning students perceptions regarding the experience developed. In a way, all of them describe positive experiences in teaching and learning methods adopted and where students expected for (responding to RQ). To sum up, ubiquitous learning environment (ULE) in flipped classrooms [15], combination of dynamic learning space (DLS) and mobile collaborative experimental learning (MCEL) [19], on-line experience [20] and gamification [16, 18, 21] in an online environment, are examples of different ways and environments that generate positive students' reactions and supports diverse learning styles of students, comparatively to conventional methods. Balancing this, students emphasize the importance of the evaluation methods, where feedback between both teachers and students is essential not only translated into grades, but also in as a continuous monitoring teaching-learning process [16]. As stated in [15], the adoption of new technologies in active teaching could "provide effective, supportive, and diverse learning experiences" and transform the learning environment into a more personalized, flexible and interactive one.

Table 1. Papers that answered the research questions RQ, SRQ1, SRQ2 and SRQ3 identified.

ID Reference, Authors, date	RQ	SRQ1	SRQ2	SRQ3
[15] Hamza and Alotaibi (2020)	x		x	x
[16] Rahman, Ahmad, Hashim (2020)	x		x	x
[17] Antera, Costa, Kalfa, Mendes (2019)	x		x	x
[18] Babichenko, Grieve, Bilodeau, Koval (2019)	x	x	x	x
[19] Bhati, Song (2019)	x	x	x	x
[20] Dwivedi, Dwivedi, Bobek, Sternad Zabukovšek (2019)	x		x	x
[21] Hasan, Nat, Vanduhe (2019)	x		x	x

Regarding the SRQ1 (What makes you a digital native? Is it enough to be born after 1980?), it was not completely answered in all the 7 documents considered being only answered in [18] and [19]. This result was unexpected since whatever the environment, the use of technology is frequent. However, this result can be explained by the change of denomination where different names for digital natives are used [22]. This could be a limitation of the study, and it is necessary a redefinition of the keywords used including, for example, "Millennials" and/or "Net generation" "i-Generation".

Considering the identification of indicators related to student engagement/ disengagement (SRQ2), the most applied word is "engagement", but it is important to consider that this engagement is different from conventional lectures [20]. In the digital environment the motivation, level of interactivity, usefulness, and feedback between both students and teachers are key aspects for a successful teaching-learning process.

Analyzing the last sub-research question, SRQ3: What are the learning scenarios, modes of delivery and educational technology tools employed in the studies?, games, and virtual platforms are the learning scenarios identified. Variety of assessment methods, from online exams to presentations and case studies [17], and possibility of a continuous follow up since students can check anytime peers' responses [21].

For a future research work, one of the objectives is to evaluate not only the technology integration but also the its use as a methodological approach, not forgetting that technology is not available equally for everyone. Still, more variable or keywords should be considered (i.e. "digital native", "technology experience", "smart") allowing a more comprehensive description of experiences in different fields of engineering. Thus, that will allow to wider perception of the engineering students attitude towards the use of new technologies in active teaching.

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An Automated Support System in a Remote Laboratory in the Context of Online Learning

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Abstract. Remote engineering and science laboratories are gaining an increased prominence due to its versatility, ease of use 24/7, most likely open and shared access to any components, setups and instruments, in reconfigurable circuits, and laboratory establishments, including quite unique and expensive ones. The remote laboratories are increasingly shared nationally and internationally mainly with a free access or less so in a pay-for-fee use. Due to the universal time-wise access, human tutoring in remote laboratories, especially synchronous is not realistic. Therefore, an automated support for the students practicing the remote experiments, missing a human tutor is being developed. The system analyses common students' mistakes in the remote laboratory and identifies remedial actions. Students are informed about their mistakes, extracted from learning analytics of the remote laboratory, in order to correct and revoke their actions. The paper reports on learning habits of the students, their backgrounds and their perception of online learning preceding and following the use of the automated tutoring system.

Keywords: Remote laboratory · NetLab · Tutoring system · Learning analytics

1 Introduction

The remote laboratory NetLab at the University of South Australia allows students to remotely perform fundamental electrical engineering, electrical circuit theory and signals and systems experiments. The remote laboratory has accommodated many thousands of learners over the years, since its introduction in 2002 and provides a secure learning collaborative environment in a potentially multinational setting, leading to independent learning in communities of practice.

The remote laboratories in the context of the coronavirus pandemic are more relevant than ever. The international and often shared use of remote laboratories is advancing rapidly and is very likely to escalate. Remote laboratories present unique benefits, but typically do not have a human tutor present to assist students. Work on tutoring systems has been ongoing for some years, providing a means of supporting students with less involvement from a human tutor.

In our work, we are adding a tutoring system to a remote laboratory system to better assist students. The remote laboratory NetLab is a collaborative laboratory, where all logged in users have a real time input in laboratory actions and view of what other users

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on the system are doing. This was originally designed so that students could work together in a group, or that a human tutor could be present to assist students. However, employing a staff of human tutors to remain logged into the system 24/7 to assist students would be unrealistic.

The goal of the study is to augment human tutors with an automated tutoring system (ATS) that can alert students to mistakes in their laboratory work, or to any significant differences between their measured results and how their circuit would be expected to behave based on relevant background theory. We do not fully expect the support system to completely replace human assistance but will measure how much students use the automated system and assess student behaviour to identify any changes in their learning process based on feedback from the automated student support system.

In the first stage of the study, student usage of the remote laboratory was examined. All student actions on the system were recorded, and from these action logs it was possible to identify common student errors. Mapping of successful and erroneous actions were systematically analysed [15]. Additionally, the practical reports submitted by students provided a way to identify any mistakes that the students made and did not rectify before submitting their work.

2 Literature Review

Remote laboratories (RL) have long been used in modern higher education. They are most often part of educational programs in the field of engineering [1–6]. Remote laboratories are a method of class placement between the computer simulation experiment and the manual implementation of a practical task. They replace the manual implementation (e.g. connecting circuits using standard connectors) of a task for a remote one, consisting of manipulating connections on a real equipment using IT tools and specialised switching devices [7].

Thanks to the development of technology in recent years, RLs are developed extremely quickly. They are based on modern solutions straight from Industry 4.0 and use the increasingly available Internet of Things (IoT) technologies [8]. These technologies replace dedicated and closed solutions in the process monitoring and process automation [1]. Modern software systems, such as MediaWiki [5] or Augmented Reality techniques [6] are also used.

RLs are created and developed as university projects [7], and now, due to the availability of technology, more and more often as rudimentary student projects in cooperation with experienced lecturers [1].

The impact of RL on study results has been studied many times. It can be observed that the attitude of students to RL changes with the civilisation changes occurring with the development and dissemination of digital technologies [4]. Students are currently people who have been using digital technologies in everyday life from an early childhood. For this part of society, the virtual world becomes part of the real world. Virtualisation of processes, including didactic aspects, is an everyday experience for them.

For example, in [2] the results of a three-year experiment assessing the impact of RLs on learning outcomes are presented. The results of examinations of three student groups using the control systems laboratory were compared: only physical, physical with additional optional RL and only RL. Comparison of survey results showed great interest in RL of the students. Analysis of exam results showed that the use of RL has a positive impact on the level of achievement of learning outcomes [2].

Despite the positive results of the research, students' attitudes to RL and the impact of their use on learning progress of the RL defect in relation to real laboratories, the disadvantages of RL are obvious. On the one hand, there is virtualisation of environments - the student does not have direct contact with the equipment in a simulated environment, but in RL the students deal with real equipment. On the other hand, there is also no contact with the academic teacher – the tutor. This contact is an indispensable element of university education, although it is changing in the era of the coronavirus.

In RL, various systems are used to support their use - from simple reservation and access systems [10] to Learning Management Systems (LMS) [11]. LMS for RLs are created as dedicated systems [12] or existing LMS are used through their integration with RL [11–13]. LMS in RLs offer a variety of functionalities, such as registration and collection of data on completed experiments (including erroneous and correct student activities), evaluation of learning outcomes, student surveys and wide possibilities of data mining with learning analytics tools [14].

3 The Remote Laboratory NetLab

The remote laboratory NetLab provides users with access to real electrical components which can be remotely controlled. Students can use the system to build circuits, experiment with different input signals and measure the output signals. These experiments can be done at any time and in any place, with the Internet access and students are given the opportunity to try many different values of real components, input signals in the circuit and view the effect.

The remote laboratory includes a function generator, a digital multimeter and a four-channel digital storage oscilloscope, all of which can be completely controlled by students as they carry out experiments. A camera provides a live image of the system, showing students that they are obtaining measurements from a real circuit, not from a simulated one. Fig. 1. Shows what students will see when using the oscilloscope to observe the behaviour of a series RLC circuit.

The client used by students/users also includes a text chat area for discussion with assignment group partners, and with the tutoring system (the lower left). The system is collaborative with up to 3 students being given access to the system at one time, and because all students are controlling the same system a list of actions is provided at the lower right of the window. This allows the students who are working together to see what their collaborators are currently doing, as they would be able to do sitting side by side in an in-person laboratory. These actions are recorded for later review in the system action log.

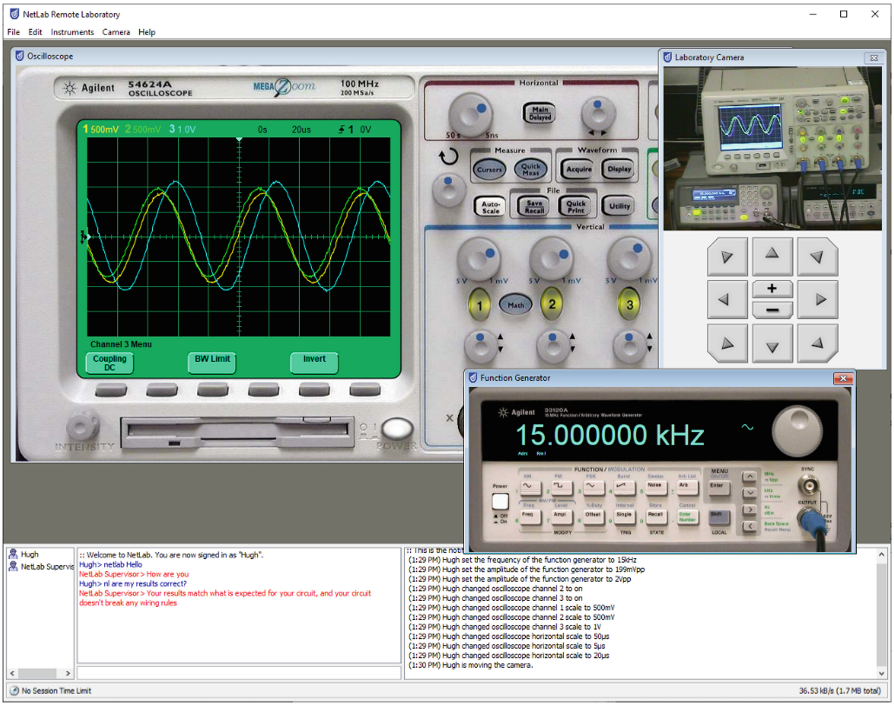

Fig. 1. Graphical user interface.

Technically, more than three students would be able to use the RL, but from experience, it may create conflicts of controlling the RL elements simultaneously.

Circuits built using the remote laboratory can include any combination of 4 resistors, 2 capacitors, an inductor and the measuring instruments available. All passive components are variable, and each can be set to any of 10,000 different values. Circuits are built by dragging and dropping components in the Circuit Builder window, and then connecting terminals by the click of a mouse. Result is shown in Fig. 2. The circuit built in the screenshot is a series RLC circuit, with the function generator supplying a variable frequency input, and the oscilloscope measuring the voltages at all circuit nodes. Unused components are shown on the right-hand side.

We have shown in previous published research [15] that student errors in the remote laboratory are highly repetitive and consist of the same specific errors repeated over and over. This suggests that an automated tutoring system can be of assistance.

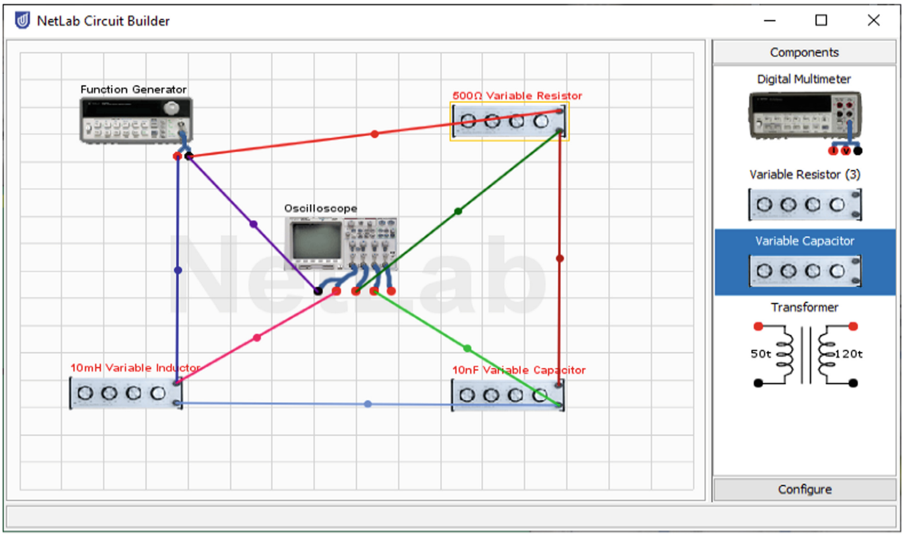

Fig. 2. The Circuit Builder.

4 ATS and Student Responses to Online Learning

Technical Details

The automated tutoring system (ATS) consists of two key components – a problem identification module, and a chat engine module. The problem identification module has a set of rules, based on past student mistakes, that allow it to recognise common problems. These common problems include wiring issues, such as short circuited components, or incorrectly connected oscilloscope signal and ground wires. The problem identification module can also recognise common oscilloscope misconfigurations, and warn students. Understanding triggering in particular can be a problem for students, and the system is able to recognise trigger conditions that the student's circuit is unable to ever produce. The problem identification module also constantly compares the measured results students are receiving from real equipment with results from a simulated model of the remote laboratory hardware. This comparison can identify further issues, such as an overloaded function generator, or incorrect oscilloscope configuration which prevents accurate measurements from being taken.

The chat engine module is responsible for all communication with the student, using the instant text messaging tool built in to the remote laboratory software. On the first login of a particular student, the chat engine introduces itself to the student, and explains how it can be asked questions. The chat engine module monitors flags that are set and cleared by the problem identification module. A unique flag is set for each particular error that the problem identifier can recognise, and another flag is set if a student makes a mistake and does not correct it within a timeout period of 2 min. If a student does not fix the mistake, the system will warn them that there is an issue they need to fix, and offer help in diagnosing the problem.

The system does not immediately tell students what problem is present – some students prefer to find issues for themselves. Those who would like assistance can ask what is wrong with their circuit, and will be given a list of what needs to be fixed.

The chat engine script has been designed to be somewhat playful, the aim being to make the tutoring system helpful during the experiment, and an amusing distraction afterwards. If someone says hello to the robot, it will greet them back. If the chat engine is unable to find an appropriate reply for a message from a student, it will initially apologise for not being able to answer. In situations where it is unable to answer several questions in a row, it will start replying with deliberately silly phrases.

Student Responses

A group of Master of IT full-time students from the Lublin University of Technology (LUT) in Poland were enrolled in their final semester in a course delivered in 2020 in English by Australian academics, called Monographic Lecture on Remote laboratories. For assessment the students had to conduct an experiment on a RC circuit using the remote laboratory NetLab and write a laboratory report in English. The lectures and the experiment were intended to introduce them to remote laboratories and give them a taste of working in one, rather than testing their circuit theory knowledge. Second year undergraduate electrical and electronic engineering students at the University of South Australia (UniSA) in Australia were also asked to conduct two experiments using the remote laboratory NetLab, and submit their laboratory reports. The students from both institutions were surveyed twice, before and after the remote experiment.

The first survey assessed the LUT students' starting point, including questions on their device usage and study habits, questions on what circuit building methods they had used before, and a short theory skills test. Responses indicated that in extreme cases the students spend some 60–70 h on the Internet and only about half of the time is study related. The Masters students' theoretical knowledge related to circuit theory and electronic instrumentation was sketchy, which is not surprising as they had those topics early in their undergraduate degree some 5 years earlier. The undergraduate UniSA students fared somewhat better in the initial skills test, but had difficulty with questions on oscilloscope triggering.

The post-experiment survey demonstrated that the Masters students improved their knowledge regarding circuit theory and understandings real instruments and components – 71% yes. Before the era of coronavirus only 7.9% of them studied online. If they had a choice, now 86% of them would prefer to study online. Some students commented that 100% of laboratories could be online. The Automated Student Support System was used by 43% of the students and of those 64% stated that it helped them to alert to circuit problems in their wiring and instrumentation setup.

Stated advantages of studying online are that the students do not need to wake up early, do not need to travel and can make study more economical, can study while at work, replaying of recorded of online sessions allows for deeper learning. The statement that teaching online is comparable with face-to face in terms of learning outcomes was supported by 57% of the Masters students (agree and strongly agree on the Likert scale), preference of either mode of delivery was indicated by 38%.

The undergraduate students from UniSA who responded to the survey were less enthusiastic about online study, with only 13% showing an interest in further online study. This may be a protest response by the on-campus students, who mostly had not studied online before, but who had all of their study moved online suddenly in week 4 of a 13 week study period in 2020 due to the coronavirus.

The undergraduate students responded positively to the remote laboratory. When asked to rank their preferred method of conducting practicals, 80% of students put hands-on practicals in a laboratory first. However, all students ranked remote laboratories ahead of software only simulation. They appreciated the understanding of the imperfection of real electrical components that the remote laboratory gave them. They also liked being able to conduct experiments from home, and being able to easily repeat an experiment if they were unsure of their results from the first attempt. Some did ask for an alternative to turning dials to set values, preferring the option of typing in values.

The tutoring system received mixed evaluations. An issue in the model of the remote laboratory used by the problem identification module to verify results caused the tutoring system to warn some students of possible errors in measurements that were correct. These students contacted their human tutor for verification. In the survey, students responded that the erroneous error messages made them spend extra time double checking their results – which produced very good results for their practical reports, but lead to some frustration. Students did like the idea of an automated tutoring system to find problems early, and several enjoyed the way that the chat engine spoke. When asked what they liked about the tutoring system, one student responded "it was cheeky". Instances can be seen in the chat logs of the system of students testing the system to see how it will reply to various nonsense messages – some light hearted moments in a stressful world.

Impact of Automated Tutoring System

A comparison of UniSA student assignments shows some improvement between 2018 cohorts, who did not use the tutoring system, and the 2020 cohort who did. The students were asked to complete very similar assignments, the only difference being the removal of a simple simulation task for the 2020 cohort, and slight changes to the component values that students were asked to use in order to prevent plagiarism from the previous cohort. With the same marker applying identical marking criteria to both groups, the mean mark for 2018 students who submitted their practical report was 75.21% (59 students). For 2020 students, the mean practical report mark was 86.48% (54 students). Several of the 2018 reports contained mistakes that the tutoring system is able to detect, but none of the 2020 submissions contained these errors.

An analysis of system action logs between 2017 and 2020 was performed using an automated analysis script. During this time, 2386 human logins and 2080 experiment sessions were recorded. The system without any student support system in place was used in 2017, 2018 and 2019. In 2020, the automated tutoring system was put in place.

Each experiment log was checked by the analysis for circuit and oscilloscope configuration errors, using the problem identification code from the tutoring system. The script counted how many changes to the circuit were made by students between an incorrect circuit being built and a correct circuit being built. When the script detected an invalid oscilloscope configuration, it counted the number of oscilloscope settings changed by the students before correctly configuring the oscilloscope again. Finally, the analysis script also counted the number of experiment sessions that ended with an incorrect configuration – typically, a student's last action should be to obtain measurements from a valid circuit before logging out (Table 1).

Table 1. Total system logins and error counts.

Year	Logins	Oscilloscope corrections	Circuit corrections	Experiments ended with errors
2017	289	5374	55	82
2018	662	9044	59	158
2019	795	9303	60	157
2020	640	8218	189	7

Comparing the two years of students surveyed and graded on the same exercise (2018 and 2020), it can be seen that a similar number of students logged in to the remote laboratory. With the automated tutoring system, students still took approximately the same number of steps to correctly configure the oscilloscope. More circuit corrections were needed in 2020, but a manual analysis of logs shows that most of these incorrect circuits were cases of students temporarily disconnecting components to measure their values with a multimeter, resulting in circuits that cause incorrect (but irrelevant) oscilloscope readings.

Most significantly, far more experiment sessions ended successfully. In 2018, 158 experiment sessions ended with a student having left the oscilloscope or circuit configured incorrectly. Some of these students exceeded their booked time on the system and were disconnected in the middle of an experiment, while others simply logged out without fixing the problem. In 2020 with the automated tutoring system in place, only 7 experiment sessions ended with a circuit or oscilloscope configuration that could not give valid results.

5 Conclusions

In 2020 evaluation 95% of Lublin students indicated that online teaching is a preferred delivery or had no preference which method of delivery is offered. This is another convincing learning paradigm preference shift toward the online teaching and learning including remote laboratories.

The automated tutoring system did not change the average number of steps taken by students trying to fix a given problem with their circuit. Future work could increase the detail provided to students when they are warned about an issue, with more specific advice on fixing an issue. However, it can be seen from the action logs and submitted practical reports that significant goals have been achieved. The automated tutoring system ensured that all students were aware of any mistakes that they had made in the circuit wiring or oscilloscope settings, and could correct these while conducting their experiment, rather than realising that they had made a mistake when reading their manually marked practical report several weeks later.

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IT and Knowledge Management in Education

Development of Knowledge Management – Transfer Approaches on the Way to a Learning Organisation Using the Example of Prison Staff

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Abstract. Prisons are in a state of constant institutional change, marked by extensive development processes. The subject of different studies is the analysis of development processes in prisons, for which suitable strategies of organizational and personnel development are required. In this context, the area of further vocational training is of particular importance, whereby this should be based primarily on the work-related further training of the prison officers. The research question that arises is how to combine work and learning in a meaningful way. The systematization of the work structures and work tasks of prison officers has the purpose of presenting their varied and demanding professional profile. The importance is closely linked to the management and communication policy in the departments, which will be presented. The complex methodology of the author includes 42 expert interviews, 51 workplace observations and 8 group discussions in three Saxon prisons in Germany. In the joint discussion, the aim should be to transfer the identified approaches to discovering learning potential in work structures and tasks to the field of technical and engineering sciences and to exchange experiences.

Keywords: Prison staff · Counselling · Learning organization · Comeptencies

1 Introduction

Prisons are in a constant state of institutional change, which is characterised by extensive development processes. In the implementation of personnel and organisational development in the prison system, further training plays an increasingly important role as a strategic and connecting element. It is unacceptable that managers in prisons are challenged to integrate the staff of the General Correctional Service (here referred to as prison officers), as the central occupational group, more closely into personnel and organisational development, but that consideration must also be given to which learning location combinations are suitable for organisational and personnel development in order to successfully manage development processes [1, 2].

The motivation for continuous, work-related learning, which is dependent on the design of work tasks and work structures that are conducive to learning [3, p. 147], is

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ideally made possible by the development of a learning content of these structures by managers. The learning opportunities created by managers' support and accompany employees in their respective work processes. Building on this, the article deals with the question of how to better coordinate the interrelated components of working and learning in work tasks and how to design them in a competence-oriented manner. Against this background, Aulerich calls for managers to support personnel development through competence-oriented learning design [4, p. 136]. Bergmann [5, p. 6] emphasises in her studies that "the scope for the development of vocational action competence is shaped by the work situation" and that "vocational action competence is a characteristic that must be constantly developed in the work process and that depends largely on the work situation. Both the academic discourse and the practice of continuing vocational training deal with the meaningful relationship between work and learning as an interdependent relationship [1, p. 5].

Accordingly, learning processes must be designed in a work-related and cross-cutting way in accordance with vocational and adult education findings so that the learning content of work structures and tasks can be used more consciously at the same time. With regard to the design of change processes and the development of the necessary competences, it has been shown that "…with forms of learning which are directly integrated into the process of work, the effectiveness is demonstrably higher than with traditional forms of further training" [6, p. 7].

The objective of the own empirical research is to describe the vocational competence of employees and the learning potential of their work tasks. According to Burgheim/Ostheimer [7], in order to cope with changes in the current prison system, the professional self-image and thus also the task profile of the staff working in the prison system is developing further. Prison officers are primarily responsible for security tasks. A new field of activity relates to the performance of "treatment tasks". These include elements of counselling and care of prisoners with the aim of supporting their rehabilitation. Although there are initial scientific studies on the requirement profiles of staff, there has long been a lack of concrete, empirical surveys on the task and competence profiles of this occupational group. The present research work helps to close this scientific gap.

2 A Brief Description of the Object of Investigation Prison

In the time frame of the investigations, the Free State of Saxony in Germany had eleven sites of correctional facilities. [1, p. 11] A targeted selection of the Saxon prisons is based on the complexity of the structural and procedural conditions of the respective organisation, which serves as a basis for discussion on the transferability of aspects of the study. With the consideration of obtaining targeted three prisons were selected. The central target group of the investigations are the prison officers involved in their hierarchical levels between the head of prison, department manager and specialist and social services on the one hand and on the other hand the prisoners' representation, visitors of the prisoners and others persons [8, 9].

The departments form the ideal starting point for investigating and documenting the design of change processes. The prison officers, is examined in the context of their work in the department as representatives of the largest occupational group in the prison system. As a preliminary study has shown, the prison officers share responsibility for change processes. At the same time, their range of tasks and scope for decision-making has expanded, which makes it possible to document the processes of change in a variety of ways and to integrate in-service training [1, p. 144 ff. and 81].

One of the investigation targets was the description of professional competence of staff and the learning potential of their work structures and tasks. In order to avoid possible conclusions about persons for data protection reasons, no reference to the assignment of the hierarchy is made here. While the results for the determination of the work structures were based on oral interviews and workplace observations, the work tasks could be analysed in group discussions. The evaluation of the interviews, workplace observations etc. is carried out using the method of qualitative content analysis based on Mayring [10] and Gläser/Laudel [11, p. 197]. The sample of investigations is made up as follows in Table 1.

Table 1. Sampling of investigations [1, p. 17]

Methods	Number of persons surveyed
Oral interviews	42
Job observations	51
Work shadowing	18
Individual conversations, group discussions	8
Quality Circle 1	5
Quality Circle 2	9
Evaluation of results and processes	14

In general, the flashback showed that the implementation of the studies did indeed create methodological problems. To quote Hohmeier [12, p. 20] "it is difficult to define the role of a scientist […]. The sensitization of the interviewees is a permanent process, because in their 'occupation-specific socialization' they have [learned] to build up a façade of external representation of their role to 'strangers'.

3 Function of Learning Counselling and Learning Support in Development Processes in Prisons

3.1 Concepts of Learning Counselling and Learning Support

The understanding of the term "learning organisation", which implies processes of learning guidance and support, is perceived differently in the prison system and defined within a range of different approaches. The term "social learning in and from institutions", which Schäffter [13] coined, is used to illustrate the interdependencies between the organisation and the further training of staff in the design of change processes, i.e. the further development of an organisation is not designed randomly in the totality of the learning processes that have been initiated, but is controlled in a targeted manner. This view of a completed event or a completed development can be described with the term learning guidance as a punctual and temporary stage in the development process. In contrast, the concept of the "learning organisation" understands "change", i.e. the change in organisational and personnel development, as a normal case that is permanently present in all organisational processes. In this interpretation, "indirect control of change" takes place as a "general, comprehensive competence of the organisation" whose process is actively reacted to by adaptation. In this understanding, the concept of learning guidance is integrated according to Görl-Rottstädt [1] as a permanently anchored process. The design of learning processes and the integration of further training as a constitutive element are seen as inherent in both views. In the prison system, organisational development is still primarily understood as a separate event in a specific period of time, although continuous improvement processes in work structures and work tasks are aimed for. According to Pätzold [14] theoretical approaches generally exist parallel to each other and only refer to each other in parts. Counselling also always implies support. Görl-Rottstädt moved to these four following contexts to explain possibilities of learning counselling in the development processes in prisons.

- personnel-oriented development processes, e.g. team development
- prisoner oriented development processes, e.g. implementation of prison profiles
- work structures, e.g. conference system, rotation, secondment,
- work tasks of the prison officers, e.g. carry out an inspection of the holding cell [1, p. 86]

In further descriptions the focus is specialized on the level of work structures and work tasks to discover the learning content during the installing team development processes of prison officers.

3.2 Learning Potentials of Work Structures During Installing Team Development Processes of Prison Officers

In her empirical studies, the author has interviewed three prisons in Saxony about the implementation of these team development processes. Prison 1 and prison 2 refer to a relatively stable status in the personnel and organizational situation due to the implementation of the concept since 2000. At the time of the investigations, the prison 3 was only in the early stages of implementing the concept. The potentials of learning sustainability through consulting and accompanying pro-cesses during the team development processes can already be clearly recognized by the following aspects:

- The early participation of all team members in the concept genesis and decision-making processes is the basis for a high motivation of the staff to accept new ideas and to actively implement them. Provided that managers are willing to participate, his attitude promotes continuous cooperation within and between teams.
- The composition of the team according to different criteria has decisively strengthened the overall competence of the team. The differentiated background of experience of the staff members, visible to others, is, when communicated, a

suitable platform for all participants to exchange experiences and to learn together in the process of work.

- The further integration of the staff in the treatment tasks strengthens both their sense of identity and their personal responsibility. Under the guidance of the managers, the staff members recognise room for manoeuvre in their work tasks and increasingly become "active" shapers of the development processes. [1, p. 89–97]

These developments are significantly supported by the integration of existing working structures, whereby work structures in author's opinion are structures which it can be understand as organized social forms that combine work and learning in work process. [1, p. 56–69 and p. 118–139] It will be illustrated by the following two examples with the background of team development processes.

1. working structure of the rotation as an example of a singular event:
   Positive for short-term rotations with the right to return to the workplace. Here, in communicative processes, the view for the work processes of other departments is gained, experiences are exchanged. The understanding for each other is promoted. It becomes problematic when different interpretations of how to deal with prisoners collide. This leads to conflicts and to a high pressure to justify oneself. But a permanent rotation of management staff can also lead to a reduction in room for manoeuvres, as Görl-Rottstädt has learnt from conversations with staff members of the housing group prison, for example. The reduction of room for manoeuvres affects job satisfaction If a prison officer is cut back in his scope of action, his motivation also decreases. The conflict situation with other staff about treatment approaches becomes all the more manifest, too. [1, p. 123–125].
2. work structure of conference system as an example of anchored in the daily routine. Managers, such as specialist and social services, see here, particularly in terms of teamwork, in their role as learning advisors and companions. The integration of staff is new for everyone involved and must grow. Elements of reflection, irritation and feedback and also the handling of conflicts characterise the structure. Job satisfaction grows through recognised integration: the conference system is a kind of free space for learning for staff. A critical factor is the discernible uncertainty in the definition of the tasks of the individual professional groups, which is associated with the introduction of flat hierarchies. By skillfully developing synergies of the competences of all occupational groups involved, team results can be significantly improved. Depending on the inner attitude of the team members, i.e. the mutual appreciation of the occupational groups and a suitable, open communication structure (such as the establishment of conference systems), the learning potentials become correspondingly visible for all those involved in the work process. The negative side is whether the conference system also receives this pedagogical character from the managers and can be developed by the team. If it is only used to pass on information, potential opportunities are lost [1, p. 134–138].

3.3 Learning Potentials of Work Tasks in the Daily Routine

If the work structures already contain these diverse learning potentials, but also lines of conflict, then it becomes all the more exciting as if the design of the work tasks is dedicated to the prison staff. Görl-Rottstädt [1, p. 141] developed a practical and theoretical reference framework and has based the theory of the complete action of Hackers [15] and indicators from KIBNET [16], a learning process guide. To assess the areas of competence Görl-Rottstädt [1] referred to the work of Erpenbeck and Heyse [17]. In the author's view, three typical forms of work tasks result in the assessment of development potential (see Table 2).

Table 2. Types of work tasks depending on the degree of learning [1, p. 149]

Task type I	Task type II	Task type III
• Check house workers • provide meals • Carry out laundry exchange • dispense medication • Bringing and fetching prisoners to work, school etc.	• Accept and forward requests • Accept and forward applications • Carry out an outdoor stay (yard exercise)	• Carry out information and opening • Carry out a demonstration of the prisoners • Carry out the relocation • Execute shift handover • Writing a disciplinary complaint • Carry out checks of the detention area • Carry out an assessment of the prisoners
no to low degree of learning potential N= 5	low to medium degree of learning potential N= 3	high degree of learning potential N= 8

While task type I is evaluated in a very formalised way during the execution of the task, the social interaction of the staff with the prisoners of task types II to III increases, which also leads to a greater scope of action during the execution. [1, p. 149–153] However, not only the processing of information is important, but also the access to all information in order to gain freedom of action. It is also a contradiction in terms to be restricted in the execution of the work task and at the same time to see the broader learning potential in relation to the design of the work structures or in the team processes. This is still a balancing act in which the employees have to work on what needs to be communicated, and is then also evident in the interaction with the prisoners [1, p. 149–153].

3.4 Approach for the Optimization of Educational Structures

As the author had already described and experienced with the staff regarding the rotation of managers, she becomes more and more aware of the importance of securing achieved standards of individual and collective knowledge and competence of a learning organization. Görl-Rottstädt (2011) proposes the need a solution for systematic learning guidance and support at the interfaces of internal departmental, internal, independent and external training. Her idea is to install a knowledge management system that is independent of individuals via the structure of the quality circle. Görl-Rottstädt [1] proposes the need a solution for systematic learning way. In the synopsis of the four following editors, the importance of learning guidance and support is given a constant dimension: advanced training in departments (1), further internal training in prison (2), Further training of the justice-related training centre (3) and independent further training (4). [1, p. 185]. Görl-Rottstädt (1) was able to install cross-hierarchical quality circles in two prisons in the process of her investigations, which have come closer to this concern in that work.

4 Conclusion

In summary, the author can say that she has achieved the target she set herself. The present studies have shown directions of development and created a basis for the correctional facilities. The author has initiated sensitisation processes, and in addition Görl-Rottstädt [1] has also been able to provide very practical recommendations for action.

It would be desirable if the learning potential of development processes, work structures and work tasks, as well as the discrepancies mentioned above, were to remain the subject of discussion in prison context, but also as example for the general personnel development in other jobs. The same applies to the further development of the task and competence profiles of prison officers and other professional groups in the team, right up to the competence-oriented design of in-service training courses. It is essential to accept that only networked work and further training structures in a knowledge management system make it possible to design current and future processes of personnel and organizational development in order to develop prisons at a high level into a learning organization and to improve the image of the prison officers.

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Requirements on Math and ICT Competences Within the Study Branches Transport and Automotive Service and Repair

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Abstract. To set the content and scope of math and ICT education appropriately is very important to achieve stated objectives of both training and education, and keeping, and also enhancing, quality performance of the work activities of the graduates of the study specialization in the field of transport and car repair. In the paper there is described an analysis, done by the authors, aim of which was to assess coincidence of the current content of the state and school education programs of secondary vocational schools with the needs and requirements of employers in the transport and motor-car repair sector regarding the math and ICT competences of their potential employees (from the point of view of the performance of the professional activities of the employees).

Keywords: Vocational education and training (VET) · Dual education system · Motor-car repair professions

1 Introduction

Math and ICT competences are an important component of the profile of the graduates of secondary vocational schools in fields aimed at transport and motor-car repair segment, as these competences significantly influence personal and professional development of the students and at the same time they significantly increase employability of the graduates in the labour market. Dual education system, introduced in these schools, increases the share of practical training at interest of theoretical education. To set the content and scope of math and ICT education appropriately is very important to achieve the stated objectives of both training and education, and keeping, and also enhancing, quality performance of the work activities of the graduates of the mentioned specialization. The strategic aim is to ensure a smooth cross-curricular continuity from general-theoretical education through vocational practical training even to the performance of professional activities (Kozík et al. 2016; Kolychalov and Pushkareva 2018).

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2 Background of the Research

2.1 Vocational Education and Training in Slovakia

The Slovak education and training system is based on the 1970s model, aimed at providing all learners with at least upper secondary education, mainly through school-based vocational education and training. As to the vocational education and training (VET), the reform in 2015, based on a new Vocational Education and Training Act (Act 61/2015), has introduced dual education and training. The new VET Act was initiated by employer representatives, mainly from the automotive industry, and it introduced a system of dual education system based on the experiences of the Austrian, German and Swiss national systems of education (Eichhorst 2015; Gessler 2017).

In the new approach, companies take responsibility for training provision. They find learners and sign individual training (apprenticeship) contracts which must be complemented by an institutional contract between the company and a secondary vocational school. This contract describes the partners' roles and responsibilities. Practical training, as a work-based learning, is provided by the employer at his workplace, which must be certified by a corresponding chamber of employers (Šebeň Zaťková and Ambrózy 2020; Barnová et al. 2020). Companies are not obliged to offer future employment to contracted apprentices. In contrast to traditional apprentices, learners in dual VET in Slovakia are students and not employees of a company that provides training.

However, the real conditions to introduce dual system of vocational education and training were not attractive and motivating sufficiently for schools and employers. The main weaknesses and problems were: excessive administration necessary to dual-workplace accreditation, reduction of funds allocated to schools entering into dual VET, limited terms and deadlines for entering into the dual education system, no financial support for employers. As a result, there was a very small proportion of students involved in dual education system. So already during 2015 there were made two amendments to the VET Act which have aimed to make the conditions for admission to dual education system more attractive. Consequently, according to official statistics, one year after the new VET Act introduced the dual system there were already 117 companies in Slovakia certified to offer training in 37 dual VET programs and 1 438 training places (CEDEFOP 2016; Hašková and Zatkalík 2018; Hašková and Zatkalík 2020).

2.2 Demands of the Labour Market

As practice shows, numbers of secondary vocational school graduates are not sufficient to cover employers' demand for the shortage workforces (CVIT 2019). One of the reasons is the current disproportion between the real numbers of secondary school students (in terms of the population numbers) and the employers' needs. Another reason is that the secondary school study fields and the numbers of the secondary school students are not planned in accordance with the needs of national or regional economy (Korbas et al. 2014). Although a new legal regulation introduced in September 2018 has delegated powers to set these plans directly to self-governing regions to follow additional labour market needs, in practice no significant change in this way has been recorded and there is still no effective tool to respond promptly to the needs of employers and to cover the demand for labour forces with respect to the particular industrial sectors (Hašková and Zatkalík 2020). A certain overview of the labour market needs, in terms of approximate estimated numbers of graduates of particular study branches that schools should produce in a given year, are offered by documents prepared by the Central Office of Labour, Social Affairs and Family of the Slovak Republic. But because of the absence of the graduate systemic tracking, macroeconomic forecasting is a more relevant source which can enable to find out relevant data to plan school performance so that there would not be shortage or surplus of secondary vocational school graduates in the labour market and which would respond flexibly to changes occurred in practice.

Based on Trexima Bratislava data, a private company that develops forecasts for public authorities, the online job portal labour market guide indicates the following 10 most frequently advertised occupations:

- mechanical machinery assemblers,	- waiters and sommeliers,
- manufacturing labourers,	- freight handlers,
- stock clerks,	- heavy truck and lorry drivers,
- electrical equipment assemblers,	- shop sales assistants,
- electronic equipment assemblers,	- freight handlers.

According to ŠIOV (2016) companies reported as the most demanded vocations the following 12 vocations:

- tool setter,	- machinery & equipment programmer,
- electrician,	- form builder,
- CNC/NC operator,	- auto mechanic,
- machinist,	- auto body painter,
- tool maker,	- auto electrician,
- mechatronics technician,	- coach-builder.

At the same time the companies reported as the vocations with the most significant insufficient qualifications these following ones:

- tool setter, electrician,	- machinery & equipment programmer,
- mechatronics technician	- machinist,
- CNC/NC operator,	- form builder,
- tool maker,	- auto mechanic, auto electrician.

The areas in which the graduates have insufficient knowledge, skills or practice varies from one of the vocation to another one, as well as the measures of the deficiencies within the particular areas vary in relation to each of the given vocations.

However, as the most frequent and at the same time most serious causes of insufficient qualification in general can be stated these following ones:

- insufficient practical experience,	
- insufficient skills:	- machinery/tool set-up/maintenance,
	- technical documentation,
	- operating machinery and instruments,
	- programming machinery,
	- assembling/disassembling equipment,
	- methods of measurement,
	- hand working and machining materials, quality control,
	- information and communication technology;
- insuf. theoretical knowledge:	- machines and equipment,
	- metal processing and machining technology,
	- electronics and electrical engineering,
	- technical drawing,
	- tools and jigs,
	- properties of materials,
	- applied informatics, work with software,
	- health and safety at work.

2.3 Creation of VET School Curricula

VET programs comprise general and vocational components defined by the national curriculum (general education and vocational training). Vocational training and education are carried out at particular vocational schools with different ratios of theoretical education and practical training. In the system of dual education employers have a very strong position and role to influence the VET provisions in VET programs. Not only that their own demands can be reflected in school curricula, they even have a responsibility to participate at school curricula creation. This responsibility of the employers has resulted from one of the reasons why the dual system of VET was introduced and that was to prepare apprentices for their future occupation after the demands and requirements of the possible/potential employers (Hrmo et al. 2016; Hrmo et al. 2013).

On the other hand, it has to be mentioned that due to the introduction of the dual system of VET the aliquot part of theoretical education compared with practical training was decreased in consequence of the legislative changes. Current ratios of theoretical education and practical training are 20:80, 40:60 or 50:50, in dependence on the group which the particular study branch belongs to. And these changes consequently have strongly influenced just math and ICT education within the education programs of the study branches Transport and Automotive Service and Repair.

3 Analysis of Coincidence of Employers' Requirements with Current Content of Education

As it was already stated before, math and ICT competences are an important component of the profile of the graduates of secondary vocational schools in fields aimed at transport and car repair segments, as these competences significantly influence personal and professional development of the apprentices and at the same time they significantly increase employability of the graduates in the labour market. On the other hand, as it was also already above-mentioned, introduction of the dual system has decreased the time allocation of math and ICT education. That was a reason why there was carried out a research a purpose of which was to assess to which measure are met employers' requirements on math and ICT competences of graduates of the education programs carried out within the study branches Transport and Automotive Service and Repair. So there were two tasks which were to be fulfilled. One of them was to process a critical analysis of the relevant current education programs of the respective study branches in relation to the items regarding math and ICT education. And the second task was to identify real needs of employers in the transport and motor-car repair area regarding the math and ICT competences of their potential employees (from the point of views of the performance of the professional activities of the employees).

The research was carried out in relation to Upper Secondary Vocational School for Transport in Bratislava, which is one of the providers of vocational education and training of labour forces for transport and transport services (Hašková and Zatkalík 2018). The school joined dual education system actively in the academic year 2017/2018 and currently it has 25 contracts on dual education system with 32 accredited workplaces and 78 contractual workplaces.

3.1 Analysis of State and School Curricula Focused on Math and ICT Education

Schools prepare their own school curricula (in form of so-called School Educational Program) based on what could be considered national curricula setting educational standards (referred to as State Educational Programs). Educational standards are composed of content and performance standards, as stipulated by the Education Act (Act 245/2008).

Hereinafter we present results of the content and scope analysis of the education programs of the group of study branches engineering, study branch autotronik in their parts focused on math and ICT education.

- According the given profiles, a graduate has knowledge from the area of engineering education (technical and electrotechnical display of components, mechanisms and functional units, orientation in professional literature, instructions, standards, tables, manuals, creation of technical documentation through computer technology) and electrotechnical education (theoretical knowledge and practical skills in repairing and adjusting electrical and electronic equipment and accessories of road vehicles, measuring non-electrical and electrical devices and equipment, their basic functions in vehicles and the possibility of their further use, diagnosing and measuring the technical condition of vehicles applying the most important safety principles and protection of health at work, in particular protection against the effects of electric current with the provision of first aid in the case of electric shock).

- Further the graduate has professional competences related to the operation and maintenance of machinery and equipment with a focus on road vehicles, dealing with customers, ensuring receipt and issue of vehicles for repair or from repair, performing repairs, setting up and diagnosing, preparing new vehicles for operation, performing organizational or service operations in technical control stations and emission measurement stations, processing of service documentation, etc.
- The graduate has knowledge also of an economic nature. With his creative approach, he is able to support marketing-oriented business activities, a target goal of which is customer satisfaction.
- In order to achieve the stated objectives of VET, in the field of math and work with information there are defined partial goals which are specified in thematic units: Numbers, variables and arithmetic operations with numbers, Relations, functions, tables, diagrams, Geometry and measurement, Combinatorics, probability, statistics, Logic, reasoning, proofs, Information around us, Principles of operation of digital technologies, Communication through digital technologies, Procedures, problem solving, algorithmic thinking, Information society.
- Key competences related to the subject of math are: to gain the ability to use mathematics in your future life and know how to use mathematical symbolism correctly, show relationships, read coherently texts containing numbers, dependencies and relations and discontinuous texts containing tables, graphs and diagrams, orient oneself in plane and space, work with instructions and create them, independently analyse the texts of tasks, and solve them, estimate, evaluate and justify the results, evaluate different solutions.

Results of the quantitative analysis of the particular topic distribution within the curricula of the subjects of math and informatics are presented in a graphical form in Fig. 1 and Fig. 2.

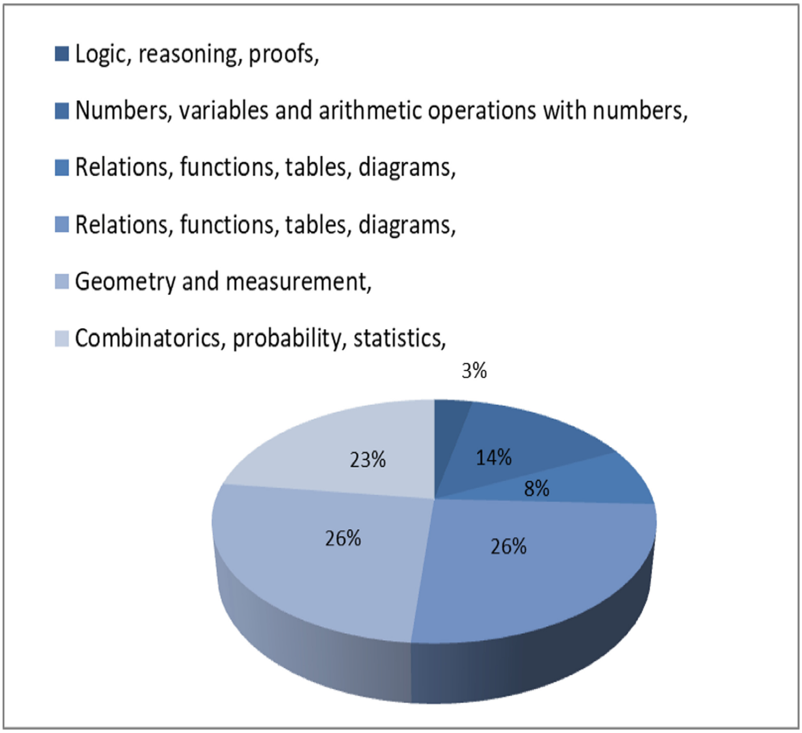

Fig. 1. Proportional distribution of the topics within the subject of math.

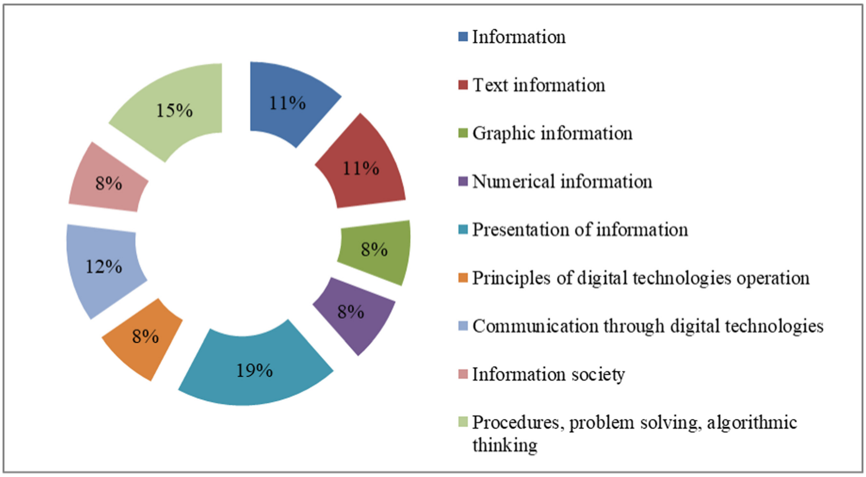

Fig. 2. Proportional distribution of the topics within the subject of informatics.

3.2 Identification of Employers' Needs and Requirements

Identification of the real needs of employers, their requirements on math and ICT competences of graduates of study and training branches of the group of engineering was done by the means of a questionnaire survey. The purpose of the survey was to find out employers' opinions on competences, content and performance standards which the employers consider to be important at exercising the profession, and to compare them with the current state, quality level of vocational training of students and apprentices at Upper Secondary Vocational School for Transport in Bratislava. Research sample of the employers – respondents of the questionnaire survey was selected on the basis of accessibility, with respect to the number of learners and workplaces in which the apprentices undergo their practice in the system of dual vocational education and training and in individual form.

Administration of the questionnaires was done by means of the electronic service electronic Google Drive service supported by the electronic post and data sharing. In frame of the administration all business entities, in which the learners of the vocational school underwent their practice in the individual form, were addressed. Finally, based on the number of the obtained fulfilled questionnaires, the research sample consisted of 24 respondents. According to the employee rating of the respondents, the research sample consisted of supervisors and instructors, workplace and operation managers, entrance technician, autoelectrician and motorcar mechanic.

The respondents assessed different math and informatics competences from the point of view of the competence significance for a successful performance of the professions belonging into the transport and automotive service and repair sectors. The assessment was based on the use of the scale:

0–20 for not needed,
20–40 for rather not needed,
40–60 for neither pointless nor needed,
60–80 for rather needed,
80–100 for much-needed.

Results of the identification of the employers' needs and requirements on math and ICT competences of graduates of study and training branches of the group of engineering are presented in a graphical form in Fig. 3 and Fig. 4.

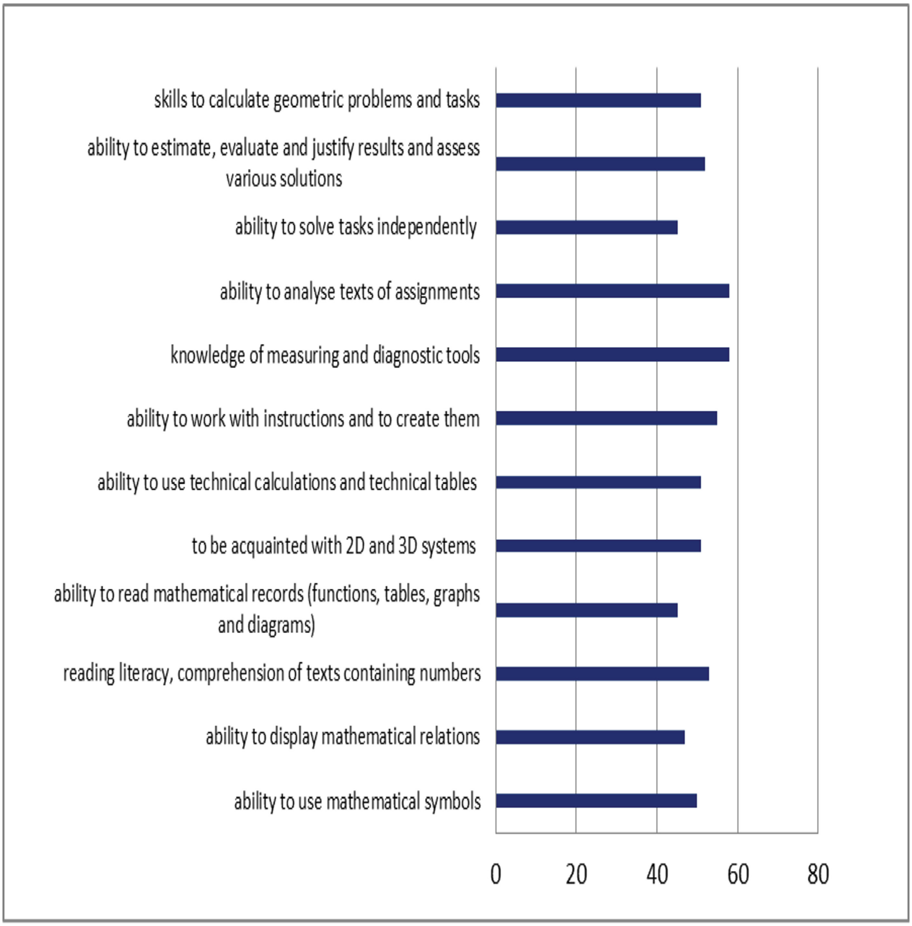

Fig. 3. Average assessment values recorded at the particular math competences according to the used scale.

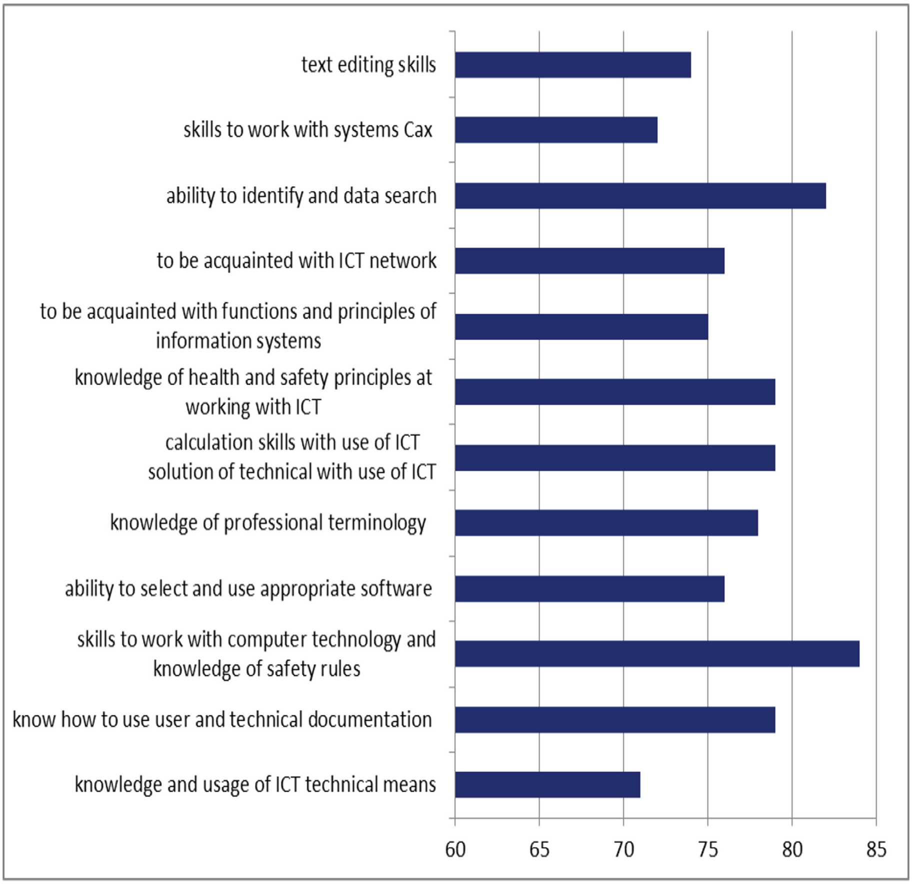

Fig. 4. Average assessment values recorded at the particular ICT competences according to the used scale.

3.3 Testing Coincidence of Employers' Requirements with the Education Content

To assess whether the employers' requirements on math and ICT competences of graduates of the education programs carried out within the groups of study branches Transport and Automotive Service and Repair are met with the current content of education there was stated a hypothesis

H: We assume that there is a difference between the content of theoretical education of the learners in math and informatics (ICT) and the needs of the learners' potential future employers,

to which the tested null hypothesis was

H0: We assume that there is no statistically significant difference between the content of theoretical education of the learners in math and informatics (ICT) and the needs of the learners' potential future employers (Table 1).

Table 1. Descriptive statistics of the tested variables.

Column 1		Column 2	
Mean	2.125	Mean	2
Standard error	0.235542082	Standard error	0.159255514
Median	2	Median	2
Mode	1	Mode	2
Standard deviation	1.153915828	Standard deviation	0.780189498
Sample variance	1.331521739	Sample variance	0.608695652
Kurtosis	0.080615761	Kurtosis	−1.30148423
Skewness	0.847963638	Skewness	4.2127E-17
Range	4	Range	2
Minimum	1	Minimum	1
Maximum	5	Maximum	3
Sum	51	Sum	48
Count	24	Count	24
Largest (1)	5	Largest (1)	3
Smallest (1)	1	Smallest (1)	1
Conf. Lev. (95.0%)	0.487255921	Conf. Lev. (95.0%)	0.329445132

Value of the test criterion is $F = 2.1875$ a $F_{crit} = 2.014424842$, what means that $F > F_{crit}$ and the assumption of equality of variance is rejected at the significance level of 0.5%. As the recorded differences were statistically significant, the difference between the variances was statistically significant so the T-test with inequality of variances was used.

If H0: $\mu 1 = \mu 2$, then the hypothesis H0 is rejected and if H0: $\mu 1 \neq \mu 2$, then the hypothesis H0 is not rejected and ES < KS or ES > KS can occur. Critical interval for the tested hypothesis is $M = (-\infty, -1{,}71) \cup (1, 71, \infty)$. According to the value of the test criterion for the hypothesis H0, the hypothesis is rejected at the significance level $\alpha = 0.5\%$ as the value t of the test criterion is not within the critical interval $t \notin M$ (Tables 2 and 3).

Table 2. Results of F-test: two-sample for variances.

	Variable 1	Variable 2
Mean	2.125	2
Variance	1.331521739	0.608695652
Observations	24	24
df	23	23
F	2.1875	
P(F <=f) one-tail	0.033323864	
F Critical one-tail	2.014424842	

Table 3. Results of t-test: paired two sample for means.

	Variable 1	Variable 2
Mean	2.125	2
Variance	1.331521739	0.608695652
Observations	24	24
Pearson correlation	0.144883587	
Hypothesized mean difference	0	
df	23	
t Stat	0.472547321	
P(T <= t) one-tail	0.320494707	
t Critical one-tail	1.713871528	
P(T <= t) two-tail	0.640989414	
t Critical two-tail	2.06865761	

4 Conclusion

The assumed difference between the content of theoretical education of the learners in math and informatics (ICT) and the needs of their potential future employers was proved in an indirect way already within the particular questionnaire data processing. Besides the above-mentioned items there was also an item at which the respondents were asked to express their opinion on the need to innovate content of vocational training and education. The need to innovate this content was assessed by 44% of the respondents as much needed, 11% as needed and 28% as rather needed. The respondents specified mainly the need to develop logical thinking of the learners, to add into the curricula also the work with the software application "Incadea" and to put more emphasis on English language acquisition.

Acknowledgment. This work has been supported by the Cultural and Educational Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic under the projects No. KEGA 021UKF-4/2018 and KEGA 017UKF-4/2020.

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A Three-Year Analysis of Engineering Students' Readiness for Remote Learning and Its Relevance to COVID-19

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Abstract. UNESCO is concerned about the impact of the COVID-19 pandemic on 1.5 billion learners worldwide. Future movers and shakers of our world are losing their valuable time due to the disruptions caused by this pandemic. Cannot they continue their learning activities from wherever they are? Technology provides teachers and students with several means to access a variety of educational resources. There has also been considerable growth in the adoption of technology within educational institutions in recent years. The world is standing on the threshold of the fourth industrial revolution, which is based on information and communication technologies. In keeping with this modern trend, data collection was done through the distribution of an online questionnaire among first-year undergraduates of the Faculty of Engineering at the University of Moratuwa (UoM) in Sri Lanka during 2017, 2018 and 2019. When preparing the online questionnaire, questions were taken from the Kirkwood & Price TEL Handbook. Results indicated that all the respondents were computer literate and of them, 80% owned computers at home. Therefore, higher educational institutions can arrange to take advantage of these capabilities to enhance the students' learning by encouraging them to adopt collaborative learning methods. Further, this study shows that more than 95% of them access the Internet by using a smartphone, and as such, higher education institutions can arrange to exploit mobile technologies for engineering education, thereby delivering the maximum benefits to students. Based on the findings of this study, it does make sense to conclude that adopting meaningful technological interventions could result in significant and positive changes in the teaching and learning practices at UoM.

Keywords: Ownership of ICT · Student's readiness · Online learning · TEL

1 Introduction

UNESCO is concerned about the impact of the COVID-19 pandemic on 1.5 billion learners worldwide [1]. Future workers of our world are losing their valuable time because of Covid-19. Cannot they continue their learning activities from wherever they are? Information and Communication Technology (ICT) has reached all corners of the

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globe and is increasingly being used for educational purposes [2]. The wide availability of mobile smart devices and accessibility to the Internet has made educational resources easily accessible to learners irrespective of time and space [3]. However, it is a hard fact that there are external and internal factors that militate against the successful application of technology for education [4]. In certain educational contexts and settings, students may not have the opportunity to use technology for their education, even though they may possess the knowledge and the skills to make use of such technology. Also, attitudes towards teaching and learning are critical factors that influence the implementation of educational technology. As a developing country we had difficulty coping with situations like a terrorist attack and COVID-19 and were forced to shut down all schools and universities for 2–4 months. Though all universities had mainly practiced face-to-face education until recently, now they had to do a sudden transformation to blended learning and distance learning.

Technology Enabled Learning (TEL) refers to the use of digital technologies that are applied to any kind of educational system to enhance the quality of teaching and learning. Kirkwood and Price [5] modeled the complexity of four interrelated factors that could influence the instantiation of effective institutional approaches to TEL, such as the teacher's academic context, the student's academic context, the depart-mental context and the institutional context. Of these contexts, our main concern is about the student's academic context. Kirkwood and Price, discussing the framework of factors that influence teaching and learning with technology in higher education, mention five factors relevant to the student's academic context; these are digital literacy, access to technology, learning practices, approaches to learning, and conceptions of learning & teaching.

2 Purpose

Technology provides teachers and students with access to a variety of educational resources [6, 7]. There has been considerable progress in the adoption of technology within educational institutions in recent years. The world is standing on the threshold of the fourth industrial revolution, which is based on information technology. To maintain the quality and the status of engineering graduates, the accreditation and assessment of academic programs play a vital role in engineering education. The engineering program is designed to cover six categories of courses: general engineering, basic mathematics and science, engineering proficiency, professional development, advanced mathematics and core education [8, 13]. Each of these categories provides the student with an essential component of their overall study program that makes sure the students are ready to work as engineers [14, 15].

Therefore, as a leading technical university in Sri Lanka we wanted to produce high caliber, well experienced engineers to serve society through enhancing the engineering degree program. We had to do this since the University of Moratuwa produces over 800 engineering graduates annually. This report marks the beginning of a journey to improve the quality of teaching and learning in the Faculty of Engineering at the University of Moratuwa, Sri Lanka. The faculty aims to (i) offer courses that integrate ICT for teaching and learning, (ii) enhance student engagement and the quality of learning, and (iii) improve the ICT skills of every learner to prepare him/ her to be a lifelong learner. The main aim of this study was to examine learners' access to ICT resources, their skills at making the best use of ICT, and assess their perceptions about using TEL for their learning in the domain of TEL in engineering education and evaluate the preparedness of the system and stakeholders to continue education in a situation like COVID19.

3 Methodology

The data collection was done through an online questionnaire that was forwarded to all first-year undergraduates of the Faculty of Engineering at the University of Moratuwa (UoM) in Sri Lanka during 2017, 2018 and 2019. The questionnaire was designed to collect students' demographic information as well as their opinions about instructional strategies and resources related to TEL environments. The demography related information was about accessibility to technology devices, gender and availability of the Internet. The online questionnaire included questions from the Kirkwood & Price TEL Handbook [5, 16]. Likert scales were used to collect the data for the statistical analysis. The objective of the Likert scale was to measure the extent of students' experience and agreement with each item. The ordinal of Likert scales was adapted from Kirkwood & Price (2016). Students were given the chance to answer the online questionnaire during the Moodle introductory session that was held at the Faculty of Engineering soon after they entered the university. First-year students were selected, as they were new to the university environment after their Advanced Level exam-oriented education and had not been exposed to technology properly yet. Students were informed of the purpose of the study and were asked to fill in the questionnaire.

Students were given to understand that their participation was voluntary and they could opt-out of the survey any time they wanted. The data were collected anonymously using the voluntary sampling method. In all, more than 1500 responses were collected. The data were compared with that of 6 other countries, i.e. Bangladesh – the Ahsanullah University of Science and Technology [17]; Kenya – Jaramogi Oginga Odinga University of Science and Technology [18]; Malaysia – Universiti Malaysia Sabah [19]; Papua New Guinea – University of Papua New Guinea [20]; Samoa – National University of Samoa [21]; and Uganda – Uganda Management Institute [22].

4 Results and Discussion

The findings show that in every year the males dominated the sample. In the Sri Lankan context the engineering industry is always dominated by males. Annual reports of the UGC Sri Lanka show that more than 75% of the engineering admissions are comprised of male students. As shown in the bar graph of Fig. 1, in the years 2017 to 2019 the Male percentage lay between 70% and 80%.

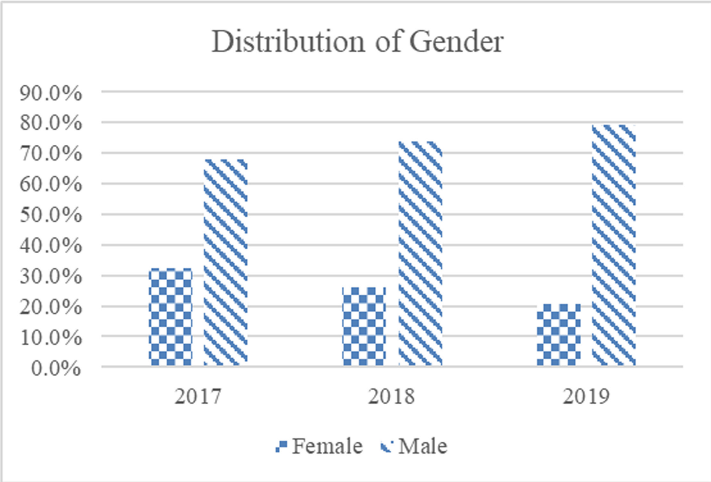

Fig. 1. Distribution of Gender for the years 2017–2019

4.1 Access and Usage of Technology

Devices Owned by the Learners: The study intended to find the availability of and access to technology. Questions were posed about the learners' own devices, Internet facility on campuses and frequency of learners' usage. According to the data, about 80% of learners possess laptops and 20% of them are planning to buy a computer within 12 months, while 44% have desktops at home and 95% of learners carry smartphones, as shown in Fig. 2 and Fig. 3. Learners have access to desktop computers at the university. However, the UoM currently does not provide laptops, smartphones or tablets for student use. More than 75% of the students use their own devices on campus, as seen from the results. The data implies that the use of smartphones for teaching-learning will benefit learners since there is a significant increase in the ownership of smartphones.

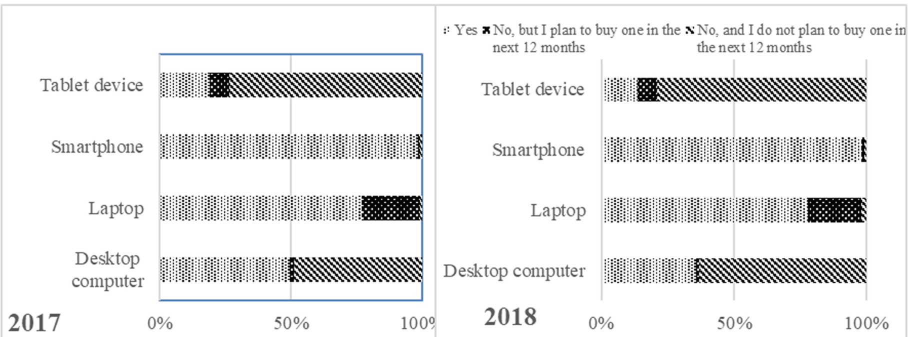

Fig. 2. Devices owned by the learners in the years 2017 and 2018

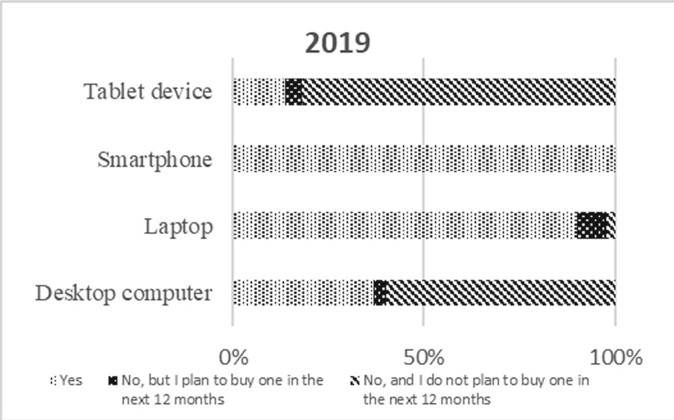

Fig. 3. Devices owned by the learners in the year 2019

Access to the Internet: Internet access is a vital element of TEL, and as such it is important to determine how easily learners can connect to it. Learners access the Internet from various places. Nearly 90% of learners have Internet access at home while about 8% of learners use the office or cyber cafe to go online. There are a few students (less than 1%) who have access neither at home nor office nor cybercafé. Figure 4 shows that 95.16% of students had Internet access at home in the year 2019, which is higher than in the year 2017.

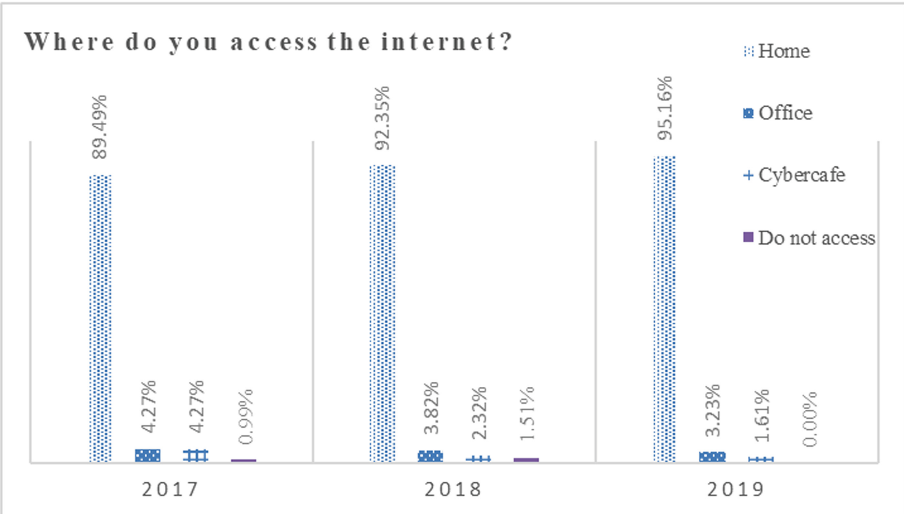

Fig. 4. Distribution of places where the learners accessed the Internet over the years 2017–2019

Sources of Internet Access: Web resources consisting of videos, web articles, teacher presentations and LMS tools were the main features of the TEL intervention. Therefore, it is essential to understand how students access the Internet. More than 90% of learners used their smartphones to access the Internet. Remaining students used the laptop for Internet access while less than 0.2% used the desktop computer, tablet or iPad for access as shown in Fig. 5. All the students used the Internet daily by using a smartphone (92.91%) or a laptop (6.76%) or a tab or desktop computer. However, it was established that 100% of the students had at least one device available for them to participate in TEL, though many had to depend on smartphones for various activities.

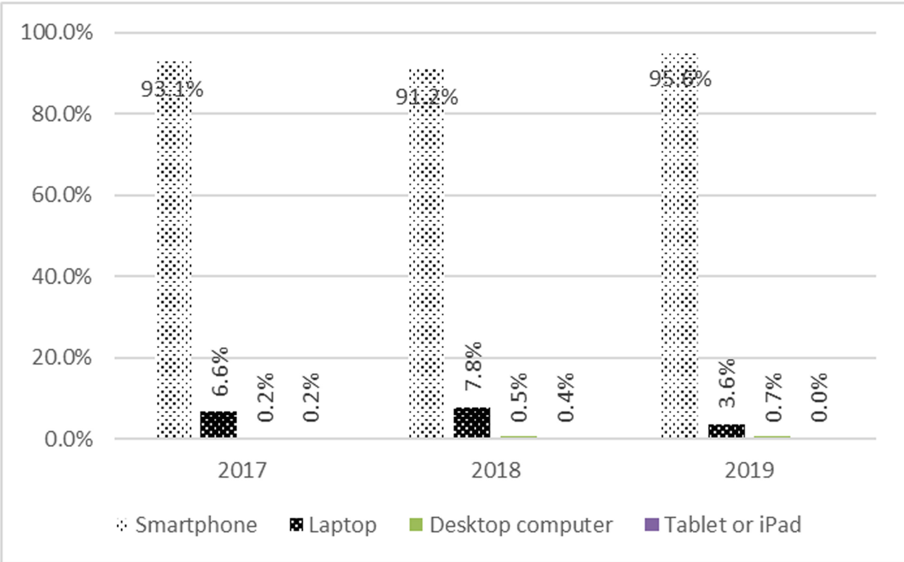

Fig. 5. Devices that learners use most frequently to access the Internet

Comfort Level with Using Computer: The competency level of learners who use a range of computer skills was evaluated through a Likert scale ranging from 5 to 1, rated as 5- Exceptional, 4- Good, 3- Average, 2- Weak and 1- Very Weak. Results indicated that learners were very proficient in word processing, spreadsheets, PowerPoint, using search engines and email, with mean responses above the midpoint or average of 3. Learners were not as proficient in areas such as graphics editing, digital and audio editing, webpage design and LMSs as shown in Table 1. This indicates a need for building up more skills. 99% of students had a social media account. Students were asked to rank their preferences in different computer-related activities. It was seen that students were keen on search engines and email related activities. Moreover, more than 50% of students had used word processing, spreadsheet and presentation software. Further, the majority of students were not familiar with Learning Management Systems (LMS), video editing, web page designing, graphic designing, digital audio editing, and databases.

Further, students were asked what sort of Internet related activities they engaged in daily. It appeared that the majority spent more than an hour daily accessing the Internet. Around half of the students were members of various IT-based forums, such as mailing lists or discussion forums. The majority did not use these forums very frequently. Students were also not used to MOOCs. Most of them strongly agree or agree that the technologies they are using at the university will help them with studying, developing skills and preparing themselves for future job markets. Learners at the UoM are aware of the usefulness of technologies in their studies for accessing academic resources, sharing resources, communicating with their peers, collaborating and other tasks. They prefer to have access to educational resources and course-related information online. They also like to use social media to connect with other students and teachers. They like to search for and download videos, texts and audio files from the Internet. However, they do not seem to be aware of or care about copyright restrictions.

Table 1. Learner's comfort level with computer skills

Computer skills	Weighted average		
	2017	2018	2019
Word processor (e.g. Word)	3.54	3.35	3.46
Spreadsheets (e.g. Excel)	3.16	3.02	3.19
Presentation (e.g. PowerPoint)	3.36	3.11	3.21
Email	3.64	3.58	3.74
Search engines	3.73	3.68	3.84
Databases	2.49	2.56	2.72
Multimedia authoring	2.17	2.33	2.51
Graphic editing	1.92	2.01	2.26
Digital audio editing	1.64	1.86	1.95
Video editing	1.76	1.98	2.05
Web page design	1.71	1.80	1.92
Learning Management System	1.76	1.97	2.58
Web 2.0 tools (wikis, blogs, social networking and sharing tools)	2.24	2.26	2.58

4.2 Learners' Perceptions of Using TEL

As shown in Table 2 learners were asked to rate how useful technologies are for their studies, regardless of whether they had used them or not. The question was to be answered by ticking a box on a 5-point Likert scale. Weighted points were given for each rating as 5- Strongly Agree, 4- Agree, 3- Neutral, 2- Disagree and 1- Strongly Disagree. The calculated weighted averages are displayed in Table 2 for the years 2017–2019. Results revealed that the markings for all statements were above average and highly positive, with mean responses above 4.0 in every year. Therefore, we can assume that learners are ready and feel motivated to work with new technologies or TEL. This is a very encouraging sign, as it means that learners are highly receptive to TEL and accept its potential value. Responses to question 5, "It allows me to collaborate with others easily, both in and outside of the campus" suggested that students were receptive to the idea of conducting their studies through PBL implementation and collaborative learning [23, 24].

Table 2. Learners' perceptions of using TEL in the year 2017–2019 intakes

Statements	Weighted average		
	2017	2018	2019
1. It will help me get better results in my subjects	4.38	4.32	4.26
2. It will help me understand the subject material more deeply	4.38	4.31	4.40
3. It makes completing work in my subjects more convenient	4.27	4.22	4.37
4. It motivates me to explore many topics I may not have seen before	4.29	4.20	4.27
5. It allows me to collaborate with others easily, both on and outside of the campus	4.13	4.15	4.20
6. It will improve my IT/information management skills in general	4.30	4.31	4.27
7. It will improve my career or employment prospects in the long term	4.20	4.23	4.18

4.3 Learner Attitudes Towards Technology

Students were asked to respond to statements on their attitudes towards technology, using Likert scale items with 5- Strongly Agree, 4- Agree, 3- Neutral, 2- Disagree and 1- Strongly Disagree. The results are presented in Table 3 for statements framed in positive terms, with learners strongly agreeing and with mean responses higher than 3. Learners did not agree that online lectures would make them more likely to skip classes. It shows the average score for the statement "I am more likely to skip classes when materials from course lectures are available online" as 2.5, indicating that learners would not skip classes even if materials were available online. Therefore, we can see if they had TEL they would still be willing to have face-to-face lectures. Our previous studies showed that they liked even video recorded lectures [10, 12]. Learners strongly agreed that technology made them more connected to the university, teachers and other students. The majority of learners showed concern about privacy and cyber-security issues, and about technology interfering with their concentration on their studies. Learners indicated they wished teachers to use and integrate more technology into their teaching.

Table 3. Learner Attitudes towards Technology

Statements	Weighted average		
	2017	2018	2019
1. I get more actively involved in courses that use technology	4.154	4.076	4.183
2. I am more likely to skip classes when materials from course lectures are available online	2.716	2.898	2.546
3. When I entered college, I was adequately prepared to use the technology needed in my courses	3.632	3.755	3.804
4. Technology makes me feel connected to what's going on at the college/ university	3.808	3.970	4.176
5. Technology makes me feel connected to other students	3.779	3.974	4.046
6. Technology makes me feel connected to teachers	3.468	3.776	3.870
7. Technology interferes with my ability to concentrate and think deeply about subjects I care about	3.462	3.708	3.642
8. I am concerned that technology advances may increasingly invade my privacy	3.425	3.631	3.388
9. I am concerned about cyber security issues(password protection and hacking)	3.620	3.833	3.915
10. In-class use of mobile devices is distracting to me	3.294	3.469	3.340
11. In-class use of mobile devices is distracting to my teacher	3.450	3.610	3.648
12. Use of tablets/laptops in class improves my engagement with the content and class	3.553	3.831	3.757
13. Multitasking with my technology devices sometimes prevents me from concentrating on or doing the work that is most important	3.547	3.674	3.615
14. When it comes to social media (e.g. Facebook, Twitter, LinkedIn), I like to keep my academic life and social life separate	3.566	3.783	4.000
15. I wish my teachers in the university would use and integrate more technology into their teaching	3.744	3.944	4.019

5 Conclusions and Recommendations

Results indicate that all the respondents were computer literate and among them, more than 90% owned computers at home. Therefore, UoM can arrange to use these capabilities to enhance the students' learning and encourage them to participate in collaborative learning. Further, this study shows that more than 93% of the students access the Internet by using a smartphone. Therefore, UoM can arrange to adopt mobile technologies for engineering education, as that will deliver the maximum benefit to students. However, students' confidence with online tools and resources were perceived to vary, and the findings suggest that students need to be supported to develop skills to engage more effectively with the opportunities that e-learning offers. Further, most of the students are able to use word processors, PowerPoint, email and search engines. Almost all of the students have a Facebook account. Students' previous experiences might offer a starting point for implementing technology into their learning. Based on the findings of this study, it is easy to conclude that some meaningful technological interventions could result in significant positive changes in the teaching and learning practices at UoM. Teachers could enhance the quality of their courses by improving content creation, content sharing and learner engagement. It was found that there is a need to ensure wider access to the Wi-Fi network on the university campus. Bandwidth should be increased so that learners and teachers have easy, uninterrupted access to educational resources, course-related information and various learning forums and social media.

Over the last three years (2017–2019) students at the UoM Faculty of Engineering became aware of the usefulness of technologies in their studies for accessing academic resources, sharing resources, communicating among their peers, collaborating, and other tasks. They prefer to have online access to educational resources and course-related information and also every one of them has a social media account like Facebook and the like to connect with other students and teachers. They prefer to search for and download videos, texts and audio files from the Internet. However, they are not well aware of copyright restrictions just as in some other countries like Bangladesh [17]; Kenya [18]; Malaysia [19]; Papua New Guinea [20]; Samoa [21]; and Uganda [22]. Moreover, learners in all of the above countries believe that integrating technologies enhances their level of engagement with their courses and helps them to connect with peers and teachers.

Furthermore, "*Digital literacy is the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital devices and networked technologies for participation in economic and social life. It includes competencies that are variously referred to as computer literacy, ICT literacy, information literacy, and media literacy*" [25]. The European Commission report (2013) has proposed a framework for the development of digital competence. It consists of five core areas: information processing, communication, content creation, problem solving, and safety [26]. In this study we can also find that the UoM engineering undergraduates possess at least basic digital literacy. By considering the above five factors undergraduates can be made competent enough to use digital technologies. Since they can search for data, information and content in digital environments by navigating efficiently, they will be able to create and update personal search strategies and interact with others through a variety of digital technologies. They can also understand what appropriate digital communication means in a given context. By sharing data, information and digital content with others through appropriate digital technologies, they will be able to create and edit digital content in different formats, express themselves through digital means, and have an understanding on how to protect devices and digital content, while guarding against risks and threats in digital environments.

By considering all of the above factors we can say that students are very optimistic about TEL implementation at UoM, with the majority of them indicating that enhanced digital skills would help them use technology for better learning. It is significant that the students are digital natives and use technology to a large extent in their day-to-day lives. However, students are not used to MOOCs and some have not heard of the term "MOOC." Increased use of the currently available Moodle at UoM, awareness of Open Educational Resources (OER) and use of MOOC will need to improve. Using technology for teaching and learning at UoM would help students become better learners, and prepare them for the challenges of the twenty-first century. By considering all the facilities available for the students at UoM it is quite feasible to plan and implement online teaching effectively in this pandemic situation as recommended by the Commonwealth of Learning and World Bank report [27]. Though we collected all of the above data before the outbreak of the COVID-19 pandemic, we found that even at that time the undergraduates were quite ready for the online teaching and learning activities. But it was the pandemic that provided the real impetus for students to start learning remotely by using Internet technologies. Since this study data shows that how these initiate, and the stakeholder preparedness made it easier for the students and staff to move from the blended environment to a distance learning scenario.

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Self-monitoring Strategies to Enhance English Reading Comprehension Skills

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Abstract. Enhancing reading skills in L1 is a real challenge in most countries from South America and it is much more complicated to improve this skill in a foreign language. In an attempt to improve the reading skill of Ecuadorian students, the main objective of this research work was to find out how metacognitive strategies, which include higher-order thinking skills (HOTs), influence the improvement of English reading comprehension. To determine the effectiveness of these strategies, a pre-test and post-test were applied to two groups of students from secondary education in a city located in the highland region of Ecuador. The sample consisted of 47 students who were divided into two groups. The experimental group was taught through a methodology that included four self-monitoring strategies that involved the development of critical thinking skills, collaborative and cooperative learning; whereas the control group was taught using conventional strategies. Results show that the students who worked with the four self-monitoring strategies: "Look, Think and Predict Strategy", "Guided Retelling Strategy", "Response Journal Strategy" and "Thinking Along with Strategy" remarkably improved the reading comprehension skills of the experimental group, while the control group increased them only in a significant scale.

Keywords: Self-monitoring strategies · Reading comprehension · High order thinking skills · Cooperative learning · Collaborative learning

1 Introduction

Many EFL students and teachers think that reading is a task that they need to perform during the classroom time just to complete a textbook exercise. However, reading is an important skill that helps learners to develop the entire process of language learning because it provides input that can be used to work on interactive and communicative driven tasks where students have several opportunities to reflect, analyze and interchange ideas. Furthermore, through reading students have the opportunity to explore different types of texts and become independent thinkers.

In Ecuador, for instance, English teachers have been following the alignments of the new curricula proposed by the Ecuadorian Government since 2016. It contains a set

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of language objectives to be reached through the improvement of language performance skills, methodological strategies, and assessment criteria with the purpose of fostering students' critical thinking.

However, there are some English teachers who do not know how to use reading strategies that empower students to reach successful achievements in all language skills. Therefore, this research suggests the implementation of self-monitoring strategies for reading comprehension that enables students to increase their higher order thinking skills [1], cooperative and collaborative learning [2].

2 Literature Review

2.1 Metacognitive Strategies

Metacognitive strategies have been investigated by several authors in last years. Baker and Brown (1984) (as cited in [3]) state that metacognitive knowledge refers to the knowledge of the learners and the ways they use strategies and tasks in reading. Metacognitive strategies can be seen as a functional approach that includes actions such as planning, thinking about learning, monitoring language production and comprehension to evaluate what students have learned. [4] states that these strategies empower students to become autonomous and confident learners since through metacognition, students learn to reflect, analyze and improve their language skills. These ideas are supported by Pellegrino (2007) (as cited in [5]), who suggests that metacognitive strategies foster students' critical thinking. In addition, metacognitive strategies refer to intentional and planned techniques that readers use to monitor their reading comprehension by being aware of their understanding and assessment of a particular strategy in reading tasks.

Metacognitive strategies also include the awareness and control of planning, monitoring, repairing, revising, summarizing, and evaluating. In other words, students learn strategies that support their comprehension (awareness of strategies) and how they carry out these strategies effectively (control of strategies) [6].

Metacognitive strategies have two components: metacognitive awareness (what we know) and metacognitive regulation or control (knowing when, where, and how to use strategies, that is, what we can do) [7].

2.2 Metacognitive Awareness

Metacognitive awareness deals with the students' consciousness of how they learn by evaluating their own learning needs. It involves the understanding of students' knowledge and necessities to accomplish a given activity. It also refers to the awareness of thinking for performing and completing cognitive tasks by fostering students' direct learning [8].

2.3 Metacognitive Regulation

Metacognitive regulation considers different planning activities to predict outcomes, follow a strategy schedule, and use trial and error corrections. The activities that represent metacognitive regulation in learning are testing, revising, monitoring, and checking outcomes. These actions are directly connected with the effectiveness of the strategy [9].

2.4 Self-monitoring Strategies

Readers are using self-monitoring strategies when they reflect on what they have read and take it into consideration to increase their comprehension abilities and improve their language skills. Furthermore, self-monitoring strategies allow readers to start recognizing their necessities, responsibilities, and reactions regarding their reading tasks. [10] pinpoint some forms of monitoring reading activities such as making connections, making predictions, making inferences, summarizing, discussing texts, and identifying the parts of the text.

Likewise, [11] claims that self-monitoring strategies foster the awareness of a given activity to comprehend and interpret the ideas in reading texts. Therefore, the metacognitive process takes place and activates students' critical thinking [12].

Self-monitoring strategies raise students' possibilities to become risk-takers, decision-makers, and independent readers. Students accomplish those significant abilities because they are challenged to read and complete tasks independently. Also, to develop these strategies it is essential to motivate students' responsibility and active participation in reading tasks that promote understanding and comprehension [13].

2.5 Higher Order Thinking Skills

These skills empower students' ability to reach better levels of reasoning during their academic performance. Bloom's Taxonomy guides students to increase learning skills while they think critically, analyze problems, synthesize, and evaluate their process of language learning [14]. [1] suggest six thinking skills which are divided into two parts: higher and lower-order thinking skills (HOTs) and lower-order thinking skills (LOTs).

HOTs enable students to apply strategies that develop learners' thinking and learning through induction, deduction, comparing, analyzing and synthesizing, decision making, and problem-solving in complex and in-depth activities [15].

Bloom's Taxonomy is not only a framework for teaching thinking; its aim involves the promotion of higher forms of thinking in education such as analyzing and evaluating. Besides, it deals with three important domains in the educational activity: cognitive (mental skills), affective (feeling, emotional areas), psychomotor (physical skills) [14].

[14] determines that HOTs are classified into three categories as transfer, critical thinking, and problem-solving. When HOTs act as the transfer, students use their learning to make sense and apply their learning. Besides, they also permit students to express themselves about any topic by applying logic, argumentation, and reasoning in their academic tasks. HOTs allow students to organize their ideas to master their potentials to solve problems, evaluate their ideas, and think critically [16]. On the other

hand, LOTs indicate the lower three levels in Bloom's Taxonomy: remembering, understanding, and applying. They are the starting part of educational levels.

Teachers should make sure to include HOTs and LOTs when planning their learning objectives to give students the opportunity to employ different mental activities that involve big or little effort required to achieve their learning outcomes.

2.6 Cooperative and Collaborative Learning

According to Vygotsky (1978), cooperative and collaborative learning are directly connected with social constructivism and cognitive developmental theories. Other exponents as Piaget (1951) states that students' collaborative learning promotes deeper reasoning through the development of students' socio-cognitive level. This type of learning promotes interactions and idea-sharing for students' success. Classrooms become in social places to interact and collaborate for a common goal. Through cooperative learning, students improve social aspects and communication skills that later, promotes the ability to be successful in the world of work [16].

Researchers have shown that humans are able to find a solution to their problems through interaction. Therefore, cooperative learning benefits students to create an atmosphere of achievement through social interactions that influence students' reflection to take decisions for solving problems [17].

For cooperative and collaborative learning, teachers can organize teamwork activities in which students work together to develop a task or project. Teachers should tell learners that when they are part of a team, they should direct all their effort to achieve a common goal, so each student is responsible for others' learning.

2.7 Independent Reader Development Strategies

According to [4], reading strategies have become a potential aspect that enriches language learning methodology because they allow students to learn in a meaningful way, unpressured by learning environment or other factors. Reading strategies are useful tools that help students to avoid struggling with text comprehension through the use of guessing, scanning, predicting, analysis, among others. In this section, we will describe how to use several self-monitoring strategies that encourage learners to take risks, make decisions, promote responsibility, and take control of their reading activities.

2.8 Look, Think and Predict Strategy

Teachers can use this strategy in the pre-reading stage. Students look at images in the text to activate their previous knowledge about the reading text. If the reading passage does not have pictures, teachers can prompt students to produce initial thoughts by reading the title of the reading text. Students need to justify their predictions by answering the teacher's questions. This strategy helps students to interpret information by looking at the pictures and predicting what is going to happen in the story based on the title. In the end, students write their predictions in a handout by explaining why they wrote those ideas [13].

2.9 Guided Retellings Strategy

Retellings direct students' responses and encourage them to recall after reading. For this strategy, students stop and retell what they have understood from a reading passage. Teachers can also prompt students to add more ideas during this process. The prompts teachers use can be questions about the main points of a text. After some sessions, students can question themselves to retell the story and become independent thinkers [13].

2.10 Response Journal Strategy

Response Journal Strategy is a diary or log created by students to promote responses to their reading comprehension. This strategy allows students to use their writing ability to interact with other students [13]. For this strategy, students keep a journal in which they write some sentences to predict the content of the text, skim it and write the main points, create questions, organize and share ideas about the reading passage. Finally, students present their journal to the class for discussion.

2.11 Thinking Along Strategy

This strategy allows students to reflect on the reading text. Students use this strategy to read and re-read to construct their comprehension. For this strategy, the teacher can provide a list of different things that students can use to reinforce their understanding during their reading.

For instance, if a reading text has a picture, students can use it to help them understand the content. Students can also make predictions based on the title of the story or on what will come next. Also, while students read, they can make a mental picture of the content of the reading. Besides, students can summarize the reading in some sections of the text. All of these activities enhance students' reading comprehension [13].

3 Language Skills

Language skills can be classified into productive and receptive skills. Productive language skills refer to the ability to produce a meaningful output. Their main goal is to share knowledge with others. Speaking and writing are called productive skills because people use them to produce meaningful sounds or symbols. On the other hand, listening and reading are considered receptive skills because during their development, people are generally passive to understand the given information either through listening or reading [18].

The four language skills are also called integrated skills because they work together during a communicative activity. This means that oral and written skills (receptive and productive skills) allow students to receive and produce the message effectively in different levels, contexts, and environments.

These four skills improve the communication process and the language skills. For instance, everyday students use more than one language skill to communicate with others. In other words, students talk while they are listening and they write about what they have read. Therefore, students demonstrate an individual ability to comprehend and produce spoken and written texts for an effective interpersonal communication [9].

3.1 Language Receptive Skills

English learning receptive skills allow students to receive information from oral or written texts to make sense. During this process, learners need to connect their previous knowledge with the new information to process ideas, give opinions, and produce new texts. At this stage, learners comprehend information in a passive process. However, what they have understood, later become in the productive skills such as speaking or writing [19].

According to [20], receptive skills are used to obtain meaning from the text. This kind of processing presents some generalities in the two receptive skills as well as differences that allow teachers to plan lessons and obtain their learning goals. In both receptive skills, the background information is a strong reference to start an activity and activate students' prior knowledge.

3.2 Reading

Reading is recognized as the receptive skill that entails responding a text. Therefore, reading effectively means understanding a written text at a word level, sentence level and whole-text level. Furthermore, it is necessary to connect the message of the text to the knowledge of the world [21].

Regarding types of reading, [22] distinguishes two types: extensive and intensive reading. The first one deals with the students' reading activities for pleasure. This type of reading fosters students' enjoyment and motivation because they have the opportunity to select what they want to read. On the other hand, intensive reading is done in order to reach academic purposes and increase their lexical skills.

Reading is also considered as a process, [23] states that it involves word recognition, comprehension, fluency, and motivation. During this process students need to:

- Identify the printed text. This process is also called word recognition.
- Construct an understanding from the text, also called comprehension.
- Identify words and make meaning from them.

Reading Comprehension

According to [24], reading comprehension is a simultaneous process that permits readers to extract and build concepts by an active relationship between the text and the reader. In addition, to define reading comprehension, it is essential to clarify some key concepts that the author uses to determine this process. They are the reader, the text, and the activity. He also mentions the abilities, capacities, knowledge, and experiences that a reader has to understand the text.

Reading texts are printed or electronic texts that allow students to comprehend written ideas. The reading purposes, process, and results are directly associated with the activities that teachers propose for understanding information. Consequently, the meaning is built through the text, activities, and reader's sociocultural background [17].

According to [25], reading comprehension is a process that demands the application of skills and strategies to get an effective outcome in learning and teaching. Students who get a good performance in reading comprehension are able to construct meaning, monitor their reading and use strategies effectively.

Since reading comprehension permits students to clarify concepts, comprehend ideas and understand information, it is important to select the best strategies to promote meaningful experiences for students to obtain an effective outcome and reading success for communication [25].

Reading Strategies

Reading strategies help students to achieve efficient reading performance. They save time and focus on activities according to reading goals. In addition, they require readers to use critical analysis because they need to analyze questions and find their answers. This means that reading strategies implicate responding to a text by understanding it first. Therefore, reading strategies are useful to connect the text message to the knowledge of the world [21].

Through reading strategies, readers are immersed in a conscious and active process where comprehension activities take place before, during and after reading. Hence, students are able to connect their reading goals and interest in the text by the application of their prior knowledge to remember, understand and retrieve general and specific ideas from the text [26].

Implications of Reading Strategies

Reading strategies are "plans for solving problems in meaning construction" (Duffy, 1993 cited in [27]). Therefore, while reading students might find a lot of difficulties to understand a text, so they need to use a variety of strategies to comprehend unknown vocabulary items and understanding texts that are not part of their background knowledge. Many organizations have discussed strategy instruction to improve reading skill. One of these is TESOL (Teaching English to speakers of other languages) that entails reading comprehension through the use of comprehensive approaches.

Self-monitoring strategies can be used for the three stages of the reading process. For instance, in the pre-reading stage, learners start individually by making predictions of what they are going to read and they can make use of the Look, Think and Predict Strategy [13]. In the during reading stage, learners do both: read the book and work with other students to share information and clarify their ideas in a confident environment. So, in this stage, learners can use the Guided Retelling Strategy and the Response Journal Strategy. In the post-reading stage, students may work cooperatively in pairs or groups to improve them communicative abilities based on the text and they can use the Think Along Strategy to reinforce understanding of the reading text [13].

4 Methodology

This study was a quasi-experimental research in which a pretest and a posttest were applied to 47 first-year students who belonged to two groups (A and B) of a secondary public institution in Ecuador. The groups were established at the beginning of the academic school year 2017–2018 by the institution authorities. Sampling was done by assigning group A (25 students) to be part of the control group and group B (22 students) to be the experimental group. Both groups of students took the pre-reading test in order to validate the information about the students' reading comprehension level.

For the pre-reading and post- reading assessment, two Cambridge KET English Tests for reading were applied in order to measure students' reading skills before and after the strategy implementation. These (mock up) tests are free online resources for teachers who are preparing students for International English Language Examinations. These tests correspond to A2 level as stated in the CEFR (2001).

Then the experimental group participated in a four-week special training with the implementation of four selected self-monitoring strategies such as: Look, Think and Predict; Guided Retelling; Response Journal; and Thinking Along Strategies [23]. To conduct and see the effectiveness of the experiment, two reading books were used "Amelia Earhart" [27] for the control group and "The Year of Sharing" [28] for students of the experimental group. The selection of the book titles was based on the students' choice. The control group and the experimental group had a total of ten lessons, which sum a total of 20 h organized into five hours each week to complete all the reading material. The control group was taught with conventional reading strategies whereas the experimental group used the self-monitoring strategies.

The lessons of the experimental group used a series of handouts and rubrics to support learning through the self-monitoring strategies. After the tenth lesson, a posttest was given to both groups to test the students' reading comprehension skills.

5 Results

This study was based on a quasi-experimental research with 47 participants who were part of a control group and an experimental group. The two groups were taught ten reading lessons using conventional and self-monitoring strategies respectively to find out which strategies were the best ones to develop reading comprehension. So, this research applied a correlative analysis of the pre and post (Table 1).

Table 1. Test for paired samples (pre-test and post-test in experimental group)

Differences for paired samples in experimental group							
Average	Deviation	Average error	95% of reliability		Tendency	Degrees of freedom	Significance (bilateral)
			Low	High			
−11,364	7,853	1,674	−14,846	−7,882	−6,787	21	0,000

As the above chart shows, the difference of paired samples in the experimental group (pre-test and post-test) are done in the following form: average −11,364 with a deviation standard of 7,853 by considering 1, 67 of error with 95% of reliability that indicates a low average of −14,846 and high average of −7,882 with a tendency of −6,787 of 21 degrees of freedom. The bilateral significance in this group is 0,000.

5.1 Final Decision

With 95% of reliability and 0.05 of level of significance, the results of data collected, analyzed and processed in both groups (experimental and control) highlight that experimental group obtains $P = 0{,}000 < a = 0{,}05$ while control group shows $P = 0{,}001 < a = 0{,}05$; given that test for paired samples shows an average of −4,400 in control group is less significant in comparison to the experimental group −11,364.

6 Discussion and Conclusion

This study aimed to find out how metacognitive strategies influence the improvement of English reading comprehension in Ecuadorian students. After, using four self-monitoring strategies: Look, Think and Predict; Guided Retelling; Response Journal; and Thinking Along Strategies proposed by [13] findings demonstrate that they promote student active participation in the classroom reading tasks. Students also develop skills to reflect on their own learning and interact with the text. Furthermore, students develop their speaking and writing skills as they have to exchange ideas with their partners to discuss the content of reading texts. The implementation of the self-monitoring strategies increases the opportunities for students to work in a cooperative and collaborative way in class, as well as, they develop students' higher order thinking skills (analyze, evaluate and create) based on Bloom's Taxonomy.

In the experimental group, there is an evident increase of reading comprehension in the students who were trained with the self-monitoring strategies (−11,364) versus the control group (−4,400). This result validates the effectiveness of the strategies for reading skills improvement. In addition, the correlation of the variables (self-monitoring strategies and reading comprehension) is clearly identified by the use of the statistical analysis that proves the reliability of this current research. Furthermore, through the implementation of self-monitoring strategies, students also became self-monitoring learners and critical thinkers.

Finally, as students became self-monitoring learners they turned into skillful individuals who chose effective learning strategies that increased their own demand for learning. It is important to remark that this research has provided evidences on the effectiveness of new strategies for learning a foreign language which contribute to students' individual development so they can become self-efficacious, motivated and persistent to solve problems.

Additionally, as students became self-monitoring learners they turned into skillful individuals who chose effective learning strategies that increased their own demand for learning [29].

Finally, it is important to remark that this research has provided evidences on the effectiveness of new strategies for learning a foreign language which contributes to students' individual development so they can become self- efficacious, motivated and persistent to solve problems [8].

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Poster: Digital and Non-digital Reading: Differences for Future Engineers of IT Sector

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Abstract. The paper is devoted to the study on how the reading format (on a computer screen and on paper) affects the effectiveness of tasks solved by students – future engineers of the IT sector. A research was held to study the impact of the reading format on composing concept maps following reading texts on paper or on computer screen. The results showed advantages in completing assignments when reading on paper.

Keywords: University students · Digital and non-digital reading · Advantages and disadvantages of reading formats

1 Introduction

The transition to the information society is accompanied by active discussions on the impact of digital technologies on cognitive processes. Different aspects of the problem are on the agenda, including psychological, technological, neurocognitive, physiological, demographic ones, etc.

Numerous studies compare reading efficiency of digital and paper text formats. The results in most cases indicate significant differences in the perception of information when reading on paper and on screens and better assimilation of information when using texts on paper. At the same time, contradicting data exist, which complicates making any final and unambiguous conclusions and determines the request for further research on the issue.

2 Literature Review

To explain higher results when using paper media, researchers note such their advantages as better assimilation and easier extraction of knowledge; more intense tactile sensory experience when reading on paper; and higher concentration and immersion into the text. As for the screen reading, hypertext tools, non-linear text structure, multimodality (interactive graphics, maps, graphics, animations and sound tracks), multifunctionality, search function, and ability to receive reference and in-depth information on hyperlinks are considered its advantages. The disadvantages of reading from screens include decreased tactility, eyes strain, and navigation difficulties.

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As research results show, the transfer of knowledge from episodic memory to semantic memory depends on the presentation format (screen versus paper): the transfer of knowledge was much faster in case of printed materials. Knowledge is better absorbed and more easily retrieved when presented in paper format [1]. Memory processes suffer as we include digital devices in the body circuit and treat them as our own external memory storage. As a result, we do not remember information that we believe will be accessible, unlike that which we expect not to be available [2]. In addition, the use of cognitive tools of digital devices significantly enhances cognitive self-esteem [3].

The differences in the cognitive processes caused by digital and non-digital formats of information delivery were revealed, as well as the influence of the digital format on activation of more facts-oriented and of the paper format – on more abstract levels of information processing [4].

On one hand, media technology fosters the development of spatial visual skills such as iconic representation and spatial visualization. At the same time, the development of visual and spatial skills negatively affects such higher cognitive processes as abstract vocabulary, attention, reflection, inductive analysis, critical thinking and imagination. Reading on screens causes reduction in the use of metacognitive strategies, such as recognition of an idea, formulation of a conclusion, holistic understanding, setting specific goals, re-reading complex sections, and others [5].

Paper provides readers with higher control over the text – the ability to highlight, write marginal notes, etc. Easier intuitive navigation over long texts allows one to build a mental representation of the text, in which the content is attached to the structure, and it is easier to return to the previous fragments of the text. It is reported that difficulties with reading from computers could be caused by destruction of mental maps of the text, which could lead to a worse understanding and, ultimately, poorer reproduction of the content [6].

Hypertexts increase cognitive requirements for the visual processing, cause additional cognitive load [7], and negatively affect reading performance [8]. Studies show that the need to follow multiple hyperlinks when reading text leads to an inadequate content comprehension [9]. It is marked that hypertext, multimodality and multifunctionality of the Web are incompatible with hermeneutic immersion [10].

At the same time, the ability of concept maps to increase the efficiency of working with hypertexts has been revealed. A concept map is a graphic organizer that displays concepts and links that show the semantic relationship between concepts [11]. It is shown that concept maps, reflecting the macrostructure of semantic relations between information nodes, contribute to the integration of information based on the mental representation of the information structure of hypertexts [12].

However, while developing pedagogical strategies and scenarios, it is important to understand whether the hypertext features of digital texts are an exhaustive reason for their worse processing or the digital text format, even without hypertext functions and being only an exact copy of paper text, is also a significant parameter that can affect learning outcomes.

A number of studies compared the results of reading linear texts on a computer screen and on paper, but the results are sometimes contradictory. In some of them, better results were obtained on paper [13], while other researches did not register significant differences between the two formats [14,15].

In explaining the differences in research results, it was suggested that the reading environment might play a role in cognitively complex tasks, such as reading complex texts [14].

To answer this question, we conducted a research to study the impact of the reading format on completing assignments on composing concept maps following reading texts on paper or on computer screen that was held with students in Computer Science and Computer Engineering and System Analysis and Management at Kazan National Research Technological University.

3 Study on Influence of Digital and Paper Text Formats on Composing Concept Maps

Two studies were conducted to register the influence of digital (desktop computers) and paper formats of text reading on the efficiency of information processing through composing concept maps.

Study 1. Forty-six students (34 men, 12 women) of the second year of bachelor's degree in System Analysis and Management participated. Research was conducted in classrooms, during face-to-face Psychology and Pedagogy classes. In half of groups which were selected randomly students worked on desktop computers (N = 25), and in the rest groups on paper (N = 21). All participants read texts devoted to different issues of Psychology and Pedagogy course. The volume of texts ranged from 1514 to 2837 words. Groups working on computers and on paper received the same sets of texts, while within the groups every student received a unique text. To minimize differences in the visual characteristics of digital and non-digital texts, texts on computer screens were presented in pdf format, while students who worked with paper texts received hard copies of those pdf files.

Students were asked to read texts within a limited time (45 min), after expiration of which access to texts for them was halted. Then they received an unexpected task to compile a concept map on the issue covered in the text. All the students performed concept maps on paper. The time for the task was also limited (30 min).

Concept maps were assessed according to following rules:

each node was valued as 1 point;
each correct connection between nodes of the same hierarchical level was valued as 1 point;
each correct connection between the lower and second hierarchical levels was valued as 2 points;
each correct connection between the second and third hierarchical levels was valued as 3 points, etc. All points were summed up.

The results were compared between groups of students who read digital and printed texts. From works of 25 students who read texts on computer screens, 21 devoted to the same issues as works of 21 students who read printed texts were selected, the other four responses were excluded from processing.

The differences between the groups were analyzed using the Mann-Whitney U test.

The results showed that students who read texts on paper received higher scores than students who worked with texts on computer screens ($U_{emp} = 104$, $p < 0.01$), which indicates a higher level of information processing and a better ability to compose concept maps. At the same time, the total number of nodes in the "digital format group" was even slightly higher than that in the "paper format group" but the difference was not statistically significant ($U_{emp} = 157$, $p > 0.05$). Students who worked in digital format, however, were not as successful in building hierarchies of nodes as their peers who worked with paper texts. Incorrect assignment of nodes to hierarchy levels and poorer map structuring, in general, led to the lower result of digital text readers.

Study 2. Forty-one student (34 men, 7 women) of the second year of bachelor's degree in System Analysis and Management participated. In half of groups students worked on desktop computers (N = 22), and in the rest groups on paper (N = 19).

The conditions and procedure of the experiment were the same as in Study 1, with one exception: the task to compile a concept map was given to students before reading, and they worked on concept maps directly in the reading process. The time was also limited (75 min).

Nineteen concept maps were selected from those compiled by digital text readers, which were devoted to the same issues that concept maps compiled by paper text readers. Three responses were excluded from processing. The results showed that students who worked with texts on paper again earned higher scores compared to those who used a computer ($U_{emp} = 92$, $p < 0.01$). In digital format, students reproduced factual, empirical information, specific data in more detail, but weaker generalized them and demonstrated poorer comprehension of theoretical information, abstract concepts and categories. Thus, the trend identified in study 1 was again confirmed.

However, when comparing the data from studies 1 and 2, it was found that students who worked with digital texts in study 2 showed better results compared to their peers in study 1, who also read digital texts ($U_{emp} = 116$, $p < 0.05$).

In general, the study confirmed that the digital or paper format for obtaining information is a significant factor affecting the efficiency of processing and structuring information using intelligence cards, and the digital format negatively affects this process.

4 Discussion

The results of the study allow us to formulate recommendations to keep in mind when developing pedagogical strategies [16] that digital and non-digital media of information delivery are not interchangeable in the educational process.

The data obtained in the research are consistent with the results of studies showing that the development of digital technologies can have an ambiguous effect on educational results; in particular, the increase in young people's digital competence is accompanied by a decrease in the development of critical and creative skills [17,18]. Current research can also be considered a confirmation of the findings according to which the very interaction with digital platforms initiates information-processing strategies aimed at reducing cognitive load, even in situations where there is no information overload [4].

When choosing a platform for the delivery of information in the educational process, one should take into account the dominant methods and features of its processing and the pedagogical tasks to be solved. Thus, digital formats are more suitable for the cognitive activity of lower levels of abstraction, for example, the study, assimilation and analysis of facts, specific data, while non-digital formats for presenting information are more efficient for operations of higher levels of abstraction, such as the formation of concepts, the study of laws and theories, data classification and systematization.

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Predicting First-Year Computer Science Students Drop-Out with Machine Learning Methods: A Case Study

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Abstract. In this paper, we describe the results of the educational machine learning case study with the aim to predict first-year computer science students' dropout in the Virumaa College of Tallinn University of Technology and determine factors that influence dropout rates. In this study two different datasets are used: (1) data obtained from the TalTech study information system; (2) students' history and study results collected in Virumaa College. To build predictive models, the following machine learning algorithms are applied: Naïve Bayes, decision trees, Logistic Regression, Support Vector Machines and Neural Networks. As a result of this study were evaluated how the dropout prediction accuracies change from the moment of the students' admission to the end of the first semester. We found, that data that were available about students before enrollment allowed to predict dropout with 70% of accuracy. Using data that obtained from first semester allowed to rise prediction accuracy to 90%. Besides, the factors were determined that are related with drop-out and that are not. Any higher education institution can conduct a similar study, since it is conducted on publicly available data from the official academic information environment.

Keywords: Students' dropout · Machine learning · Prediction

1 Introduction

From 2012 to 2019 Virumaa College admits 412 students in Computer Science curriculum. During 2012–2016 231 students studied in college in Applied Computer Science curricula. 162 out of 231 students dropped out and on average 43% of the admitted students dropped out in the first academic year. In 2017 new modernized curriculum – Telematics and Intelligent Systems - entered into force, in which 181 students were enrolled during 2017–2019. Considering that Virumaa College does not require attendees to have State Examination results, in particular level, and it is enough when attendees have graduated on an upper secondary level with GPA at least 3.5, it gives opportunities for many people to start studying at higher education level. However, in this case, quantity and quality are not always compatible, and after experiencing difficulties on first year courses, many students give up. That partly explains the high drop-out rate. In the new curricula, high dropout rate during 2012–2016 was taken into

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account and 1st semester courses are rearranged to 2nd and 3rd semester, and partly integrated into other courses. This way the student's workload on semester was reduced without losing in quality in order to decrease first-year students' dropout. Unfortunately, the dropout rate remained at about the same level. One of the main goals of the college is to reduce student dropout rates by carrying out introductory interviews with student candidates and executing a mentoring program.

First year drop-out prediction model helps to achieve these goals. Current model that is created using Machine Learning predicts whether student drops-out during the first year and shows what is the probability of such event. This model does not discover the causes of drop-out neither gives the solution. If prognosis will be positive, mentor support will be executed. Mentor then will advise student in order to help to solve student problems and to introduce him/her to the students' support group.

The process of creation prediction models also helps to formulate questions for interviewing student candidates, in order to assess their maturity for particular curricula and higher education in general.

2 Background and Related Work

Student dropouts can happen at every level of education and in every curriculum. The problem is investigated, but there is no universal solution [1]. First substantial explanation for university dropouts was given by Vincent Tinto in 1975, who also proposed student-university integration model. After the advent of digital information systems, universities accumulate huge amount of data, that allows researchers to find latent trends in data using data mining techniques. Many universities in the United States and Europe started to analyze learning data, including creation of prediction models. Higher Education Commission of Tennessee conducted an analysis of a successful first year student, who started in one university and then moved to another [2]. Karlsruhe Institute of Technology in Germany carried out Computer Science student's dropout analysis [3]. First year student dropouts are investigated also in the University of Washington, in United States [4] and in the Technical University of Denmark [5]. Students drop-out is a general problem and the most researched are student dropouts in Computer Science and Technology curricula. While Computer Science and student's graduation rate in nominal time is less than in other curricula. A study conducted in Estonia found that demographics, student income, motivation, performance in the university, student's psychological condition, institutional characteristics and year of studies influence student dropout [6]. Another study that was done in Estonia did not confirm widespread anecdotal evidence as if most of the dropouts are caused by the wrong choice of specialty [7].

3 Methods

3.1 Datasets Description

Our datasets are based on student's data from two Computer Science curricula's. Two different information systems were used - SAIS (Study Admission Information System, www.sais.ee), which is used by 38 Estonian educational institutions from different educational levels and Study Information System ÕIS that is used by Tallinn University of Technology (www.ois2.ttu.ee). Datasets include following information: study information, personal data and data about previous educational institution described in Table 1, where calculated attributes are marked with (c).

Table 1. Attributes.

	Attribute	Description	Value
Data available at enrollment	Gender	Student's gender	female; male
	Age	Age at enrollment, in years (c)	17–64
	Month_ birth	Student's month of birth	1–12
	Citizenship	Student's citizenship	2 levels
	County	County in which the student resides (c)	15 counties
	Ida_Viru	Student is from Ida-Virumaa (c)	1 = yes; 0 = no
	Years_btwn	Years between entering college and graduating from a previous school (c)	0–43
	Schl_lang	Language of school	Estonian; Russian; other
	Math_state_ex	Mathematics state exam score	0–100
	School_GPA	School cumulative grade point average	0–5
	School_level	Level of education of graduated school	3 levels
	Vocat_schl	Student graduated from a vocational school (c)	1 = yes; 0 = no
	School	Secondary school student graduated from	>50 schools
	Year_enrol	Year of enrollment	2012–2019
	Study_form	Form of study	daytime; session-based
	Free_of_charge	Indicator of first-year free of charge study	1 = yes; 0 = no
First year study	SGPA _1_sem	First semester weighted average grade based on all exams	0–5
	ECTS_1_sem	In first semester accumulated credit points	0–47
	Mat_anal	Student's grade in Mathematical Analysis	0–5
	Math _refresh	Student's grade in Refresher Course in Mathematics	0–5
	Iinform_grade	Student's grade in Informatics	A (pass); M (fail)
	English_grade	Student's grade in English language	0–5

General students' academic performance data (Table 2) were used in the preliminary analysis and in the calculation of the predicted class attribute Y.

Table 2. Students total academic performance.

Attribute	Description	Value
ECTS_total	Total accumulated credit points	1–287
SGPA_total	Total cumulative SGPA for all study	0–5
NSS	Number of semesters studied	0–15
Exm_reason	Reasons for exmatriculation	5 reasons
Status	Indicator of study status	Graduate; drop-out; enrolled
Dropout_sem	Dropout semester	0–7
Y	Indicator of first-year drop-out	1 = yes; 0 = no

In each year there were 30 to 70 candidates who want to study in Computer Science curriculum. From 2012 to 2019 average dropout percent was 43% by the end of first year, therefore, we can say that our dataset is balanced in relation to the predicted class attribute. Dropout reasons are presented in following graph (Fig. 1).

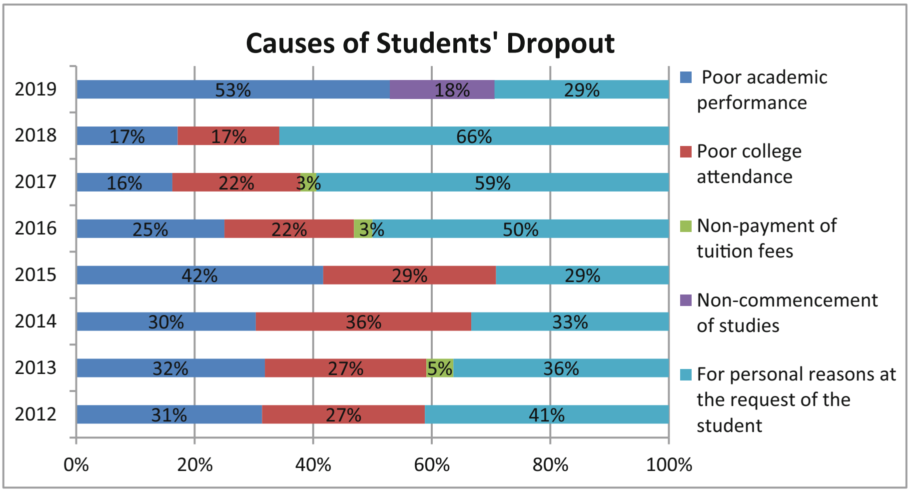

Fig. 1. Causes of students' drop-out by year of enrollment.

During the preliminary data analysis, we found that females had slightly higher dropout rate. Often, they leave on their own initiative. The dropout was not dependent on form of study (stationary or session-based). Dropout does depend on where the student obtained the upper secondary level education. Also, it was found that most of dropouts occurred with students who belong to age group 28–32.

3.2 Data Pre-processing

Preprocessing procedure included substitution of missing values and finding outliers. Missing value replacement is presented in Table 3.

Table 3. Missing values replacement.

Attribute	Number of missing values	Replacement value
ECTS_1_sem	117	0
ECTS_total	117	0
SGPA _1_sem	146	0
Math_state_ex	165	Based math state exam score
Mat_anal	65	0
Years_btwn	2	Age-18
County	20	'Unknown'
Exm_reason	174	'enrolled' or 'graduate'
Iinform_grade	76	M (fail)
Math _refresh	57	M (fail)

Missing values were mostly substituted with zeroes, because they occurred when a student missed the test, not declared a mandatory course, etc. Missing mathematics state exam scores for 2014–2016 enrolled students were replaced using the corresponding year mathematics state exam scores by the formula: mean - standard deviation considering the type of school that students graduated, i.e. upper-secondary or vocational school.

Attribute Age had outliers: 75% of students are in age up to 29 years, 25% are older and only 9 (2% of all) are older than 42 years. Among those 9 outliers 5 dropped out on the first year. In this study outliers were left in the data set.

3.3 Data Analysis and Experiments

Freeware data analysis package Weka was used for generating models [8]. The following machine learning algorithms is used in our experiments to generate prediction models: decision trees, Naïve Bayes, Neural Networks, Support Vector Machines (SVM) and Logistic Regression.

Experiments carried out on the datasets, where 2012–2018 students data from old and new Computer Science curriculum are combined. We excluded students' data, who came in 2019, because their first year is not over yet. These datasets contain data about 367 students.

Each dataset was split into 80/20 - training and testing data accordingly. For validation we used 10 times repeated 5-fold cross validation in order to obtain more stable model quality assessments. We compared our prediction results using accuracy. Experiments were divided into two stages. On the first stage, for the purpose of early dropout prediction, we generated models on data that was available before admission of students. In the second stage, we included data that were obtained from first semester.

In order to determine important factors that are related to dropout, and for taking these into account in designing further college admission interviews, over 33 different sets of attributes were used for model generation in both stages. We began with the minimal possible set of attributes, Math_state_ex and School_GPA, data always available at admission. Then we generated models with the maximal set of all possible attributes in order to study their effect on increasing model's accuracy. Further, attribute sets were composed using Infogain Attribute evaluation method and dependent attributes removing.

4 Results

4.1 Prediction Accuracies with Different Attribute Sets

The best prediction models accuracies and used attribute sets in first and second stage presented in Table 4. As our datasets were balanced, the baseline prediction accuracy that can be achieved by chance is 50%.

Table 4. Sets of attributes and best models' accuracies for stage 1.

Stage	Attributes	Best models	Accuracy, %
Stage 1	Math_state_ex, School_GPA	Logistic Regression	**70.00**
		SVM	**68.46**
		Neural Networks	**67.34**
		Naïve Bayes	**67.24**
	Citizenship, Gender, Ida-Viru, Math_state_ex, School_GPA, Schl_lang, Study_form, Vocat_schl	Logistic Regression	**66.22**
		SVM	**65.52**
		Neural Networks	**62.41**
	Citizenship, County, Free_of_charge, Gender, Math_state_ex, Schl_lang, School_GPA, School_level, Study_form	Logistic Regression	**63.10**
		SVM	**62.76**
		Decision Tree	**62.24**
Stage 2	ECTS_1_sem, SGPA _1_sem	Naïve Bayes	**90.05**
		Neural Networks	**89.68**
	ECTS_1_sem, Free_of_charge, SGPA _1_sem, Study_form, Vocat_schl	Naïve Bayes	**90.12**
		SVM	**89.70**
	Gender, County, ECTS_1_sem, Free_of_charge, SGPA _1_sem, Study_form, Vocat_schl	Naïve Bayes	**89.95**
		SVM	**89.78**

As we can see from Table 4, using data that is available before the study (Stage 1) - namely State Math examination result and previous school GPA - were enough to predict student's dropout with 70% of accuracy. Adding data from first semester (Stage 2) improved prediction result up to 90%. In the 2nd stage, the sum on ECTS and student's GPA were sufficient attributes to make prediction over 90% of accuracy. However, some additional attributes as Study form, whether the student was studying free of charge, and whether the previous school was vocational school, had some role to play in improving prediction result. In the next section we took a closer look on different attributes and how they are related to dropout.

4.2 Most Distinctive Attributes

As mentioned before, on the first stage, when we used the data available before student admission, the best model was generated using only two attributes – Math State examination result and average grade from previous school. The generated logistic regression prediction model was following:

$$dropout = \frac{1}{1 + e^{-(3.42 + MathStateEx* - 0.02 + SchoolGPA* - 0.73)}} \tag{1}$$

While State examination results were in scale 0–100 and GPA in scale 1–5, the coefficients in this model do not reflect the real importance of an attribute. When we standardize attribute values, the according coefficient values will be for Math_state_ex - 0.35 and for School_GPA -0.27, which mean that low Math state examination result is stronger dropout predictor than GPA from previous school.

In the second stage, when data from the first semester was available, the best prediction model used 5 attributes. Here we present (Fig. 2) decision tree that had an accuracy of 88.54% and used 2 attributes – ECTS in 1st semester, and whether student comes from vocational school.

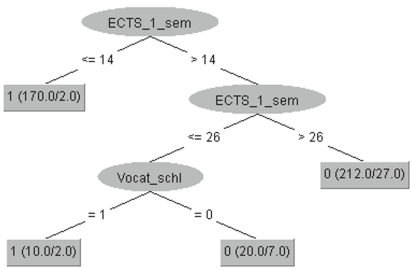

Fig. 2. Decision tree with semester data.

As we can see, the decision tree starts with most important attribute, which is the number of ECTS points student got during first semester. When it was less than 15, then the model predicts dropout, otherwise when a student got more than 26 ECTS, drop-out is not predicted. In all other cases the next important attribute is whether a student comes from a vocational school or not. Coming from vocational school predicts drop-out.

5 Conclusion

Our goal was to create models for students' first year drop-out prediction, and to find the factors that influencing drop-out. It was found that when using data that is available before the student's enrollment, student average grade from previous school and State examination result in mathematics, will predict dropout with 70% of accuracy. State Examination result in mathematics was found to be the most distinctive attribute with pre-enrollment data. Adding data available after the first semester raised prediction accuracy above to 90%, which is consistent with previous studies [3]. Most important attribute in this stage was amount of study in ECTS credit points on the first semester. We also found that some of demographic data are related to dropout, as for example the type of the previous school.

We also experienced during the process of data preparation that some of important data were incomplete, for instance, State examination results. So, we had to replace these missing values with somewhat questionable derived values. Requesting that information right before admission, could help to generate more accurate models based on pre-enrollment data. Also, we believe that, models can be improved, if we adjust the previous school GPA with some coefficient that reflects the level of that school. It can be done, for example, by comparing attendee's GPA with his/her state examination result.

Our study is limited to the data we had and therefore further study is needed to find out if some additional data could improve prediction models. At least, we got some insight about directions what might be important and what is not, and it helps to design interview questions and tests for student candidates, and to collect additional demographic details.

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WorldSkills Competition as an Efficient Engineer Training Technology

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Abstract. The article covers the phenomenon of the positive impact of the WorldSkills championship movement on improving the training of engineers at universities. Technologies of training young professionals developed in the WorldSkills championship movement have been effectively applied in universities in the last years. This applies to improve the content of educational programs and curricula.

WorldSkills movement allows future engineers to improve their professional skills in working professions related to the future profession of engineer. The training base and training ground for students are being improved, direct contacts with different companies and representatives from the government are being formed during competitions.

Experts claim that approximately every country in the world will encounter a lack of personnel in key sectors of the economy by 2025. We observe a rapid shift to the digital economy and see how new competencies are emerging and existing ones are developing. In 2020 the situation with coronavirus confirms the relevance of a rapid shift to the digital economy and improvement of existing competencies. Therefore, WorldSkills movement plays an important role in these processes.

The consequences of existing trends in the development of the global economy are job cuts, the appearance of new people, and retraining staff to the digital economy and destruction of the usual mechanisms «guarantees of the future» (career guidance, long-term employment, and decent pension). These statements were cleared up with the support of Young professionals [1].

On the other hand, there is a declining interest in engineering professions all over the world. Nowadays only a small percentage of young people choose technical specialties and engineering education. Therefore, one of the most important problems is the awakening of young people's interest in engineering specialties from school days and while studying in colleges [2].

All over the world technological and engineering universities try to persuade young learners and students to study technical studies and engineering professions as a possible future career. That is why it is important to make new informal and other methods of developing an interest in engineering professions [3, 4].

International Young professionals WorldSkills movement has a crucial role in the process of training and teaching youngsters to adapt to new realias. And also provide engineering universities with effective methods and technologies for attracting talented young people to engineering professions and training of future engineers.

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Keywords: Engineering education · World Skills Championship · Professional skill competitions · Young professionals · Engineers training · Description of the project

1 Background Goals and Problems

The purpose of our study is to study, analyze, and transmit the experience of engineering universities in conducting WorldSkills championships and the participation of students of pre-university programs, and then junior students of the university.

Kazan National Research Technological University has a successful experience in implementing various innovative projects to develop students' special competencies (e.g., in field of moral education, elite engineering education) [5, 6].

A working group was created within the framework of the project, which was developing specific mechanisms for its implementation, establishing links with government and representatives of the technology business.

We assume that the specific format of WorldSkills championships allows students of pre-university programs and first-year students to successfully improve their professional skills and competencies which are relevant to the modern economy. During the preparation for the championship future student masters the working profession which is close to his or her future engineering specialty. This suggests that WorldSkills methods can be successfully used not only with direct participants of WorldSkills competitions at various levels (regional championships, national championships, European championship, World championship, etc.) but also future participants can be trained directly in the departments and faculties of the university.

The WorldSkills championship is a non-profit movement that has been developing around the world since the mid-40s of the 20th century. However, some countries were involved in it only in the 21st century. Nevertheless, they already see and feel a significant effect of the WorldSkills championship in terms of increasing the prestige of working professions and the development of professional education. And it's not a coincidence because during the organization and holding of WorldSkills championship we can observe the best professional standards that occur in every country and the world in general.

Universities were engaged in the WorldSkills championship a little later than colleges and technical schools, but over the past 3–5 years, they have already gained experience in organizing competitions and qualified training for its participants.

The main purpose of the project is to develop the WorldSkills championship movement at the university and the formation of technological competencies and skills among future students, the involvement of high school students and college students, as well as first-year students in the process of mastering working professions, the basics of engineering activity in digitalization of Economics and Industry 4.0.

Another important goal of the project is to make working and engineering professions popular. A growing number of young people (about 42%) go to the vocational education system. This suggests that the importance of working professions is increasing, the prestige of this education is increasing. However, the domestic system of vocational education requires changes taking into account modern standards and advanced technologies [7].

WorldSkills movements can influence the improvement of engineering training at the university, therefore, the project should implement the best WorldSkills standards in the educational process of the university.

Assistance in the implementation of these goals of the project: partner-enterprises, future employers, governmental structures, ministries, and departments.

2 Stages of Project Realization

Representatives from the university have been participating in WorldSkills movement since 2016 for many years. For several years, the university has become one of the leaders in its region and country in several competencies at once, university students have repeatedly become winners in European and world championships. These results were the outcome of the tedious work of a large team: administration, teachers, and students.

A working group was created at the university, which was engaged in the development of specific mechanisms for its implementation, establishing relationships with interested partners, the dissemination of WorldSkills technologies and standards at different faculties of the university, college and lyceum as part of the project to develop the WorldSkills movement.

A working group consisted of representatives from the university, teachers, and many others who later became experts and received certification from Worldskills movement.

The development of the project in the university evolved through different stages within 5 years:

1st stage – planning and adjustment phase (2016–2017).
2nd stage – organizational phase (2017–2018).
3rd stage – competitive phase (2017–2020).
4th stage - disseminating the experience phase (2018–2020).

During the first stage, we were investigating world experience of WorldSkills movement, its development in our country. And we also made methodological documents about training college, junior students, and prepared documents about mechanisms of further participation of the university in the championship movement.

At the second stage, relations were established with partners, training sites began to be prepared both at the university itself and based on partners—industrial enterprises, companies, organizations, and ministries. And preparation of future participants in several competencies began, a pool of experts and trainers among the teachers was formed.

In the third stage, the university was intensively involved in the competitive process. For the first time in our country, a qualifying university stage was held at our base, during which a team of participants and professional experts - compatriots was formed. Since 2017, the university annually holds university qualification championships according to WorldSkills standards, at which university students, future engineers who also have a working profession, demonstrate their knowledge and skills.

The university team began to participate in regional and national championships. Several competencies were assigned to the university, according to which the participants showed themselves most actively and where the university was able to organize equipped training grounds and a base for competitions. For example, at a university college, regional championships “Young Professionals” (WorldSkills) are held.

At the fourth stage, the university generalizes the accumulated experience and extends it to all faculties of the university. Training grounds are beginning to be used in the educational process of the entire university. At the university, training is conducted for participants from other cities and from all over the country. University coaches and experts conduct classes not only with regional participants but also with national teams.

For example, university professors have become coaches of the national team in the fields of “Fashion Technology”, “CAD Engineering Design” competencies, and are preparing teams for the European Championships in Professional Excellence (EuroSkills 2018) and the World Championship.

For example, in 2019, the university becomes one of the country's ten centers for training participants in the WorldSkills movement in the CAD Engineering Design competency. At the department of computer engineering and computer-aided design, training was held for the extended national team of Russia in the CAD Engineering Design competency.

As a result of tedious work, the university became the lead organization for the training of members of the national team from our region in some WorldSkills competencies. By the decree of the Government of the republic, several engineering competencies were assigned to the university: “Laboratory Chemical Analysis”, “Printing Technologies in the Press”, “CAD Engineering Design”, “Industrial Design”, “Production of Polymer Materials”, and “Entrepreneurship”, “Refrigeration and air conditioning”. “Fashion Technology”, and since 2019 – “Labor Protection”. This means that together with the supervising ministries, the university organizes not only competitions but also the training process of participants.

One of the strategic tasks of the university is to develop the championship movement.

3 Successes of Students at Worldskills Championships

During the preparation and participation in different competitions, university students became experienced participants and they moved from young professionals (from 14 to 16) to seniors (from 17 to 22).

University students have won all the necessary places in higher educational institutions in the world according to WorldSkills standards at the time when they studied at the lyceum in the university, at a technological college, at the faculty of secondary vocational education. Then they became university students.

For example, the participation of KNITU students in the world championship of working professions in Abu Dhabi in 2017 was a brilliant success: Vadim Polyakov in the refrigeration and air conditioning competency won the gold medal there.

In 2017, Fedor Shadrin, a student of the faculty of secondary vocational education of KNITU, became a member of the WorldSkills national team. Student Albert Mineev won the EuroSkills-2018 Championship of Workers.

In 2019, university students at the regional championship won the entire pedestal in the competence "Printing Technologies in the Press", also assigned to our university. KNITU was also represented at the championship by Evelina Altunyan, Oscar Arslanov, and Emil Miftakhov. Professor Anzhe Khayrullina became a part of international certified experts. Representatives of the university won half of all the medals of all participants from the region.

Nikita Baryshev won the gold medal of the 45th WorldSkills World Championship in August 2019 in Kazan, Russia, in the competence "Industrial Design" from the technical college of our university.

4 Preliminary Results and Effects of the Project

Every year, the number of competencies in which college and university students take part is growing, the number of participants from universities is growing, and the championship's geography is expanding.

Students participating in the competitive movement demonstrate in the learning process, not only good training in the chosen professional field but also mobility, the versatility of knowledge.

According to the Minister of Labor, Employment and Social Protection of our region, the WorldSkills championship is aimed primarily at creating and strengthening the prestige of working professions, however, the results of admission campaigns to universities in recent years have shown a steady tendency to increase the competition for engineering areas. Representatives of the leadership and the government of the region have repeatedly expressed satisfaction that universities, which are training professional teams, as well as the expert community, have joined the young professionals movement.

As a result of the development of the WorldSkills movement, the professional community develops and improves professional standards. These changes are accordingly reflected in the educational programs for the training of engineers and further in the curriculum for training students in the relevant specialties.

Meetings and discussions of such changes take place among representatives of the university community with WorldSkills experts and employers. In the future, these changes in the curriculum will affect teachers of both foundation and special courses.

As for the impact of WorldSkills technologies on the exam system and the educational process of the university as a whole, it is obvious that the results of the training work of students, as well as the winners in competitions at various levels, are obvious. The methodology of evaluating the results used in WorldSkills can be directly applied to the system for evaluating university courses (in points or in another way). In the educational process, first of all, in the organization of practical and laboratory classes, methods of organizing the training of participants, as well as testing the assessment of professional skills, can also be applied. Universities and its pre-university structures also successfully use the training base for preparing for the championships in their educational process.

Universities and its pre-university structures also successfully use the training base for preparing for the championships in their educational process. Partner universities and employers provide their facilities for the preparation for the championship and holding it. Besides, some employers and sponsors, as well as government agencies, purchase the necessary equipment, simulators, etc. for the university. All this helps to improve the practical training of young professionals - participants in competitions, as well as university students in general, who can use this equipment in the educational process.

It is difficult to overestimate the educational effect of participating in competitions for students themselves. They gain valuable professional experience, develop new competencies necessary in future professional activities, immerse themselves in the real environment of professional activity, learn about professional standards. They train and work in real professional facilities and simulators that maximally recreate the production process. The best teachers in the university become certified as WorldSkills experts, as a result, they significantly enrich their practical experience, which they can successfully pass on to all students of their courses.

5 Summary

We tried to summarize this experience based on our university and partner universities. Our observations and analysis, which we constantly update with new examples, demonstrates that during the WorldSkills championships new standards are set for working professions, as well as engineering professions close to them. Besides, WorldSkills formats can affect the educational process and exam system in colleges and universities.

Our experience shows that the training base and training ground for students are being improved, direct contacts with different companies and representatives from the government are being formed during competitions.

The experience of universities in organizing and holding WorldSkills championships proves its positive impact on improving the training of engineers at universities.

Technologies for training young professionals evolved in the WorldSkills championship movement have been effectively applied in recent years both in pre-university structures and in the university itself.

This applies to improve the content of educational programs and curricula, the practice of assessing the knowledge and skills of students. WorldSkills formats allow future engineers to successfully improve their professional skills in the working professions associated with their future engineer specialties. They gain professional experience, learn necessary competencies, find out professional standards. Teachers become certified as experts and transfer their practical skills to all students.

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Real World Experiences

Poster: Socio-cultural Adaptation of Foreign Students at Kazan State Power Engineering University

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Abstract. An initiative within the Education Ministry of the Russian Federation is to develop education in general, and higher education in particular, as a revenue generating export of the Russian Federation. Russian higher education is highly regarded in the world as a result of the major intellectual milestones achieved in past years. However, there are a few obstacles to success in this area. The Russian language is not broadly studied. There are few Russian courses given in foreign languages in particular English being the most well recognized international language and Russian cultural can be intolerant to diversity. To study these challenges, a survey of 50 foreign students at Kazan State Power Engineering University was completed to study these challenges in the hopes of generating solutions that would make it easier for foreign students to integrate and be comfortable at a Russian university. Key observations: Russian language is still a big problem. Lack of security and discrimination are big issues. The students gravitated to their own community for comfort rather than integrating into Russian student society. New advancements are needed in language pedagogy, in cross cultural organization and structures to help the students bridge the cultural gaps and in diversity education for the university itself and beyond into the cosmopolitan community regarding discrimination.

Keywords: Foreign student · Integration · Adaptation · Diversity · Russian language

1 Higher Education as an Expanding Russian Export

1.1 Rationale

The Russian national initiative “Education” was launched in 2018 with the following two goals:

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1. Modernization of vocational education to include the introduction of adaptive, practice-oriented and flexible educational programs and
2. At least double the number of foreign citizens studying at educational institutions of higher education and scientific organizations, as well as implement a package of measures to employ the best of these students in the Russian Federation.

By 2025 the target is to have over 710,000 foreign students with an expected revenue of 400 billion rubles [1].

For the project to be successful, the attractiveness and competitiveness of Russian education in the international market for educational services must increase and, as a result, significantly increase the amount of revenue from educational exports services. The implementation of this priority project must improve the conditions of the students' stay during their studies in Russia, as well as increase the recognition and brand status of Russian education in the international educational market. To increase the attractiveness for educational programs for foreigners, it will be necessary to develop and implement a model of the university's activities in the export of education.

The integration of the modern Russian higher education system into the European one poses new challenges and conditions required for the export of educational services. This is directly related to the increasing competitiveness of Russian universities in the international education market, with the economic benefits of both educational institutions and the country's economy as a whole. In this sense, those universities that have established network partnerships with both foreign universities and business partners are winning [2].

In addition, the education of foreign students is a strong indicator of the status of an educational institution in the international ratings. The fundamental theoretical nature of Russian education makes Russia attractive to foreigners, and traditionally students from different countries come to Russian universities to study. Within this context, it is important to study the problems that foreign students encounter when adapting to the educational process of a Russian university.

1.2 Challenges Facing Foreign Students in Russia

Adaptation is an integral, multifaceted phenomenon and is treated in various fields of science. From the point of view of biology, adaptation is the adaptation of organisms to the conditions of their existence. Adaptation in the educational process ensures adequate interaction of the person with the social and intellectual environment of the university. It allows the formation of new personality qualities and professional identifications. Within a new societal construct, new social norms, the development of new social roles and the acquisition of new values are possible.

Adaptation to the educational environment of a university forms human behavior and has the same components as any other adaptive process. The adaptation of foreign students to the educational environment of a Russian university is understood as the multifactorial process of entry. The development and formation of the personality of a foreign student in the educational space of the university is part of a complex combination and interaction of information-functional and sociocultural fields.

The sociocultural adaptation of foreign students at a Russian university is a complex multidimensional process of interaction between the individual and the new sociocultural environment, during which foreign students, having specific ethnic and psychological characteristics, are forced to overcome various kinds of psychological, social, moral, and religious barriers to master new activities and forms of behavior.

Young people who come to study in Russia from other states find themselves in a very difficult situation. Student life is a serious test for them. They are forced to not only learn to study at a higher educational institution preparing for a future profession, but also to adapt to a completely unfamiliar sociocultural space. The difficulties that a foreign student experiences is recognized to be particularly acute in their first year [3].

2 Survey to Validate and Expose Gaps in the Assistance Needed for Foreign Students to Adapt

2.1 Structure of Survey

In order to identify problems of socio-cultural adaptation to the educational process, we conducted a sociological survey of foreign students of Kazan State Power Engineering University. The study involved 50 people whose demographics are shown in Fig. 1.

As can be seen, most of the students are male (70%) and second year students (60%). Most of the women were second year students. Most of the respondents are citizens of the former republics of the Soviet Union (90%). The remaining 5 students (10%) are African Nigerian.

Year 1		
Country	Male	Female
Nigeria	0	0
Turkmenistan	14	0
Uzbekistan	3	3
Year 2		
Country	Male	Female
Nigeria	5	0
Turkmenistan	7	10
Uzbekistan	6	2
Total	35	15

Fig. 1. The demographics of the survey group was diverse in gender and nationality (n = 50).

A multiple-choice questionnaire with options for flexibility was created to identify the main difficulties that foreign students experienced in adapting to a Russian university. The questions are listed as follows:

I. Why did you choose to study at a Russian university?

1. The prestige of Russian education.
2. Good quality education.
3. The availability of budget places and the possibility of admission to them.
4. Learning the Russian language or the ability to improve its level of knowledge.
5. Own option ____

II. The main problems of social adaptation. What was the most difficult thing for you in Russia?

1. Living conditions in the hostel.
2. Lack of peace and security/racial discrimination.
3. Russian food.
4. Everything is too expensive.
5. Cold climate.
6. Own option ____

III. What did you like when you came to study in Russia?

1. Girls/boys.
2. The nature.
3. The attitude of people around.
4. Studying at the university.
5. Independence.
6. The city and its attractions.
7. Culture.
8. Availability/support of compatriots.
9. Local cuisine.
10. Own option ____

IV. How are things with the knowledge of the Russian language?

1. I did not know Russian at all when I arrived in Russia.
2. I now speak Russian very poorly.
3. I can talk on everyday topics, but it's hard for me to learn.
4. I understand when I hear Russian, but it's hard for me to express my thoughts.

V. Who provides you the most support in the adaptation process?

1. Compatriots.
2. Office of international relations.
3. Teachers.
4. Dormitory neighbors.
5. Curators.

VI. The main problems with learning Russian.

1. Shy of my mistakes.
2. I'm afraid to speak Russian.
3. I spell words incorrectly.
4. Poorly grasping pronunciation.

5. Complex grammar.
6. I confuse vowels (е, й, ё, ы, ю, я).
7. I put stresses incorrectly.
8. The teacher speaks very quickly.
9. A difficult way to explain the material.
10. The textbooks are too difficult.
11. In the classroom, there is not enough explanation.
12. There are few simple texts in textbooks.
13. The item is not in electronic form.
14. There is no access to modern information.
15. It is difficult to get the right material on the subject.

Own option ____.

VII. What is your relationship with university management?

1. The administration shows attention and care in relation to foreign students.
2. The administration always helps if I ask.
3. I can't say anything bad or good.
4. The administration does nothing for international students.

The questions are mainly aimed at obtaining basic information about foreign students, about their social attitudes and sociocultural problems that accompany living in Russia.

2.2 Discussion of the Survey Results

Motivation for Selecting Russia. When asked why they chose to study at a Russian university, 66% chose affordability and the high possibility of admission. However, there were large differences between nationalities. The Nigerian students were all male and picked the quality (80%) and prestige (40%) of Russian education over cost. Only 30%, and 20% for students coming from the Central Asian countries, viewed quality and prestige as drivers in their choice.

Overall the students from the Central Asia countries picked lower cost and higher probability of getting in as the top motivating factors (66%) and even higher for women from these countries (80%). This is due to the fact that in Russian universities there is a project "Compatriots", which allows citizens of the former republics of the Soviet Union to have additional benefits when entering Russian universities.

Problems for Adapting: Safety, Discrimination and Cost. The living conditions in which students live directly affects the success of adaptation in a new place. Several problems with adapting to Russia were evident from the survey. One of the strongest problems seems to be a sense of insecurity and experiences of racial discrimination. Overall 64% of the students felt a lack of security and had experienced discrimination. 44% of respondents said that they were subjected to racial discrimination on the street and at the university; 20% of respondents say that their rights are violated in the service sector: shops, laundries, hairdressers, banks. These feelings were even stronger with Nigerian students (80%) and Uzbekistani women (80%). It is interesting that 2nd year students felt even less secure that first year students increasing from 50% t0 73%.

The second problem that was revealed in the survey was the higher cost of living in Russia. 58% of respondents noted excessive cost as a problem. Living conditions in the hostel were a problem for 24% of respondents. And students from Africa (10%) noted that the climate was too cold.

Positive Feedback. The respondents' answers to the question about what the foreign students liked upon arrival in Russia are interesting (question III of the questionnaire). Men liked the presence of compatriots (97%), independence (71.5%), and women (63%); while women liked nature (80%), the city and its attractions (53), culture (60%), university studies (40%), and local cuisine (20%). For 2nd year students the biggest change was an increased value for independence (71% overall and 100%).

The Russian Language. As the survey showed, the most important obstacle to the expansion and growth of Russian education as an export is the language barrier (question IV). Overall, 54% of the students came to Russia with little or no facility in the Russian language.

Almost 50% of the women came with no Russian language vs 23% for the men. However, after a year, 78% were able to have a casual conversation, could understand reasonably well but had difficulty expressing themselves. For 2nd year students, their proficiency improved significantly to the good understanding level (57% up to 85%).

The students identified several difficulties with the Russian language. Frequent spelling and pronunciation mistakes were common. However, the worst difficulties were reading Russian textbooks (84%), lecturers speaking too rapidly and not clearly enunciating (68%) and insufficient explanation of difficult concepts (58%). These problems are exacerbated by the traditional lecture mode of pedagogy that is prevalent in Russia. The majority of foreign students on question VI of the questionnaire noted that the main difficulties they had were with points 8–15 (80%). These areas offer great potential for improving the adaptation of foreign students to Russia. The development of corrective modules, as well as additional materials for foreigners, will simplify adaptation and make Russian universities more attractive to them.

Sources of Support. An important role in the course of sociocultural adaptation is played by compatriots studying in the same or other Russian universities. The respondents noted that they receive the most significant assistance and support in the process of adapting to life in Russia precisely from their compatriots (74%). They help the student to master the situation, provide the necessary information, help in mastering new social roles, establishing social contacts. Men overwhelmingly counted on their compatriots 80% vs 60% for the women. The women counted on the international office 73% vs. 40% for men. An exception was Uzbekistan men where 73% counted on fellow students in the dormitory while the Uzbek women looked to teachers (60%). Both male and female Uzbekistani students utilized the international office more than the other international students.

Effectiveness of University Support. When it comes to evaluating the responsiveness of the university institutions, the general assessment was the university supportted them well only when asked (overall 64%). The feeling got stronger in the 2nd year students increasing from 50% to 73%. This area is another opportunity for improvement in the university's system to be more proactive in understanding what the problems are and looking to offer solutions.

3 Proposed Solutions

3.1 Effective Students Organization

Interpersonal interaction and mutual understanding between local students, students representing different cultures within a group, faculty, and the academy are some of the most important conditions for successful socio-cultural adaptation of foreign students to a new educational environment. The next condition, inextricably linked with the previous one, is the inclusion of the foreign student in practical intercultural communication activities.

The process of adaptation into a new sociocultural environment takes place both in the framework of educational activities and during extracurricular activities, which helps to accelerate this process and forms speech and sociocultural competence. In order to familiarize students with the Russian reality and cultural values of Russia, it is advisable to be proactive, to organize excursions to museums; field trips to the cultural and historical memorials of Kazan and its suburbs; and cultural trips to theaters, sports and entertainment centers; to visit the libraries of the city, and to hold theme nights. It is necessary to attract foreign students to actively participate in events held by both the academy and other universities: "Mister University", "Student Spring", "Miss University", the club of fun and resourceful, sports and creative sections, concerts, scientific conferences, international festivals, intercollegiate competitions and competitions. These are obvious ways to improve adaptation. And for the most part, they already exist in universities. The key is to add international diversity in the present events or create new events with the intercultural tone.

An excellent model for this structure is Slovo, an interactive linguistic based volunteer organization at Petrozavodsk State University (PetrSU) in the Republic of Karelia. In February 2019, the Slovo International Agency project was recognized as "The Best System of Working with Foreign Students and International Student Cooperation" [4]. "Slovo" means "Word" and is not just for students of PetrSU, but also is intended to engage the whole university community in assisting foreign students to adapt. The organization draws in school children, citizens and volunteers from the community to watch and discuss films together, to share national dishes and their national cultures, to learn to communicate and understand each other, and to travel in the region and learn and experience the Russian culture. Events such International Cuisine Night and a Language Fair are examples that bring the broader community together.

3.2 Transformation of Pedagogy

Less obvious, but no less important, is the adaptation in the learning process. Improving the quality of education, having a clear professional motivation, organizing the process of adaptation of foreign students to the educational activities in the new sociocultural environment should become part of educational policy. An effective solution to the identified problems of adaptation to the educational process will ultimately contribute to the formation of a positive image of the country in the global intellectual and political community. In this case, the use of active teaching methods as part of classroom work is a solid foundation for such a transformation. Using hands-on activities, inter-disciplinary project training and active engagement of the students mitigates some of the problems that dependency on Russian language imposes [5–7]. Kazan State Power Engineering University has developed methodological and didactic conditions for the design training of all students including foreigners. At the same time, foreign students who will work in inter-ethnic teams will develop both hard skills, for which they generally come here to gain, and soft skills that are vital for them, both for effective socio-cultural adaptation in the Russian university environment, and in their future work with us and at home. For now, employers note the undoubted need for future workers to have soft skills, including: sociability, ability to work in a team, ability to defend one's opinion, ability to choose the best solution from several proposed by a team, and leadership qualities.

3.3 Diversity Education

As noted above, one of the most serious issues is the feeling of insecurity that foreign students experience. That insecurity and lack of safety is closely linked to racial discrimination. For this initiative to be successful, this issue cannot be ignored and must be addressed. Diversity training and cross-cultural interactions starting with the university community and expanding to general community are essential.

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Experiences from a Pilot Project to Efficiently Add Subtitles to an Open Source Lecture Recording Environment

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Abstract. With the availability of affordable high-quality recording hardware and video management platforms lecture recording becomes a popular service for students at a steadily increasing number of universities. Since each university has its own infrastructure and general conditions, the introduction is still an individual process requiring a lot of technical know-how and a clear definition of the workflow process. At our university, we currently have about 740 recorded lectures, providing students access via our Learning Management System (LMS) Moodle and via an open source video portal. With a main focus on barrier-free access to learning material in general and hearing-impaired students in specific, we wanted to provide subtitles for all recordings. In addition, subtitles are also very helpful for students who do not have German (our main university language) as their mother tongue. Subtitles should be at least in German, preferably also in other languages in order to support foreign students (such as Erasmus) at our university as well. In this paper we will share our experiences how to efficiently create subtitles in a semi-automatic way. Furthermore, we will share the lessons learned with the introduction of the Open Cast platform and which technical workflow we particularly defined. This workflow is optimized for a moderate growth of recorded lectures – hence feasible for small and medium sized universities – and ensures a maximum of quality. It can be easily adapted to other universities.

Keywords: Automated lecture recording · Closed captions generation · Recorded lectures

1 Introduction

1.1 Background

With the availability of affordable high-quality recording hardware and video management platforms lecture recording becomes a popular service for students at a steadily increasing number of universities. Since each university has its own infrastructure and specific requirements, the introduction is still an individual process requiring a lot of technical know-how and a clear definition of the workflow process. At our university, the introduction took three years, including one pilot year [1–3]. In

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August 2019, we finally could establish the final video management system and playout platform with the Open Source product Open Cast Matterhorn [14]. We currently have about 740 recorded lectures in our system, providing students access via our Learning Management System (LMS) Moodle and via a video portal [4]. With a main focus on barrier-free access on learning content in general and on hearing-impaired students in specific, we wanted to provide subtitles for all lecture recordings. In addition, subtitles are also very helpful for students who do not have German (our main university language) as their mother tongue. Subtitles should be at least in German, preferably also in other languages in order to support foreign students (such as Erasmus) at our university as well.

1.2 Purpose and Goals

However, creating subtitles manually is a human resource intensive process consuming a lot of work time. Hence, we performed research in order to save human resources on one hand and maximize the quality of the closed captions on the other hand.

In this paper, we want to share our experiences how to efficiently create subtitles in a semi-automatic way. Furthermore, we want to share the lessons learned with the introduction of the Open Cast platform and which technical workflow we particularly defined. This workflow is optimized for a moderate growth of recorded lectures – hence feasible for small and medium sized universities – and ensures a maximum of quality. It can be easily adapted to other universities.

For hearing-impaired students, subtitles are essential in order to efficiently study with recorded lessons. Besides that, not all students have German (main study language at our university) as their mother tongue, subtitles significantly help to improve the level of understanding. This is also true for environments with background noises (e.g. when watching the lectures on a mobile device on the bus) or you do not want to disturb other people and earphones are not available.

We had three main research issues:

1. efficiently creating subtitles for about 170 recorded videos, which corresponds to about 200 h of video, and a moderate growth
2. finding a standardized format for the subtitles, which is human-readable and easy to be edited and
3. creating an adapted technical workflow, which enables the seamless integration of the subtitles into our existing open source video management and playout system.

2 Technical and Organizational Solution

In connection with the first research issue, we identified a number of commercial services, which offer a professional speech-to-text-conversion. In comparison to a simple creation of a text script, you also have to consider time codes in connection with subtitles. This is because each piece of text (referred to as “cue”) has to be synchronically placed at a specific time in the video. This leads us to research issue

(2) finding a proper standardized format for representing the text and the corresponding time codes.

After a short market research, we found the format WebVTT [5], which is a W3C recommendation. It fulfils our requirements: it is a human-readable ASCII based format, hence it can be easily read and edited with a text editor by a human and it can be imported into our OpenCast platform to be displayed by the Paella Player [6].

We solved research issue (3) by expansion of our existing technical workflow by adding automatic audio improvement [7], splitting the audio during import into OpenCast, and sending the audio file to a transcription service. Meanwhile, the two uploaded video streams (teacher video with audio, transparencies / PC output) are published on our video portal and via LTI on our LMS Moodle. After return of the audio transcript a manual improvement step is added, then the finalized subtitles are added to the already published video and are immediately available for the students.

Before we focus on the set of tools used in order to efficiently produce and process subtitles, we will first explain our technical workflow for the production of recordings. This will provide a good overview how we apply all necessary steps in practical life, how they are integrated in our infrastructure and into the open source Software OpenCast before we go into detail on the specific steps necessary for the subtitles generation. This workflow can be easily applied to other universities.

2.1 Technical Workflow

In Fig. 1 the entire lecture recording process is visualized. The first step is preprocessing which contains the scheduling of the recordings. Since we have a central planning of the curriculum at our university, we ask teachers to provide recording wishes in advance. The lessons are then scheduled in the appropriate rooms equipped with the recording hardware. Additionally, we also provide requests on demand – in this case we try to re-schedule the lesson to one of the recording rooms – and recordings during live lessons. In the later we get a message of a new recording and contact the teacher right after the lesson for further steps.

Preprocessing and Recording

We decided to equip our lecture rooms with Epiphan [13] hardware, which met our technical requirements. All in all, we equipped five big lecture rooms, the aula, three seminar rooms and our clinical skills simulation center with recording hardware and with a camera. The recording interface can be easily controlled via a touch panel directly placed in the lecture rooms. The camera films the white board and the teacher, next to this the PC/Beamer output can be recorded. Both streams are recorded in full HD resolution. Furthermore, we provide the teachers with four recording pre-settings. The first setting records PC/Beamer and the teacher's lectern, the second setting records PC/Beamer and the teacher's lectern and the whiteboard, the third setting records PC/Beamer and the whiteboard and the fourth setting records whiteboard and teacher's lectern but not the PC/Beamer. These easy to understand recording scenarios together with the record, stop and pause button – see Fig. 2 - is the entire interface for the teachers in order to fully automatically record their lessons.

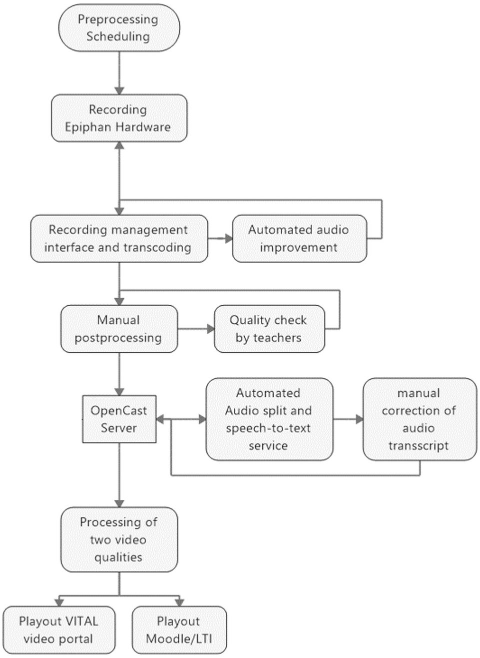

Fig. 1. Technical recording workflow including subtitle generation

Fig. 2. Teacher touch panel interface for recording management

Recording Management Interface and Automated Audio Improvement

After recording is done the data is automatically transmitted as a MPEG-2 transport stream containing both video streams synchronized to a storage. Here we programmed an interface which allows administrators to manage and control the recordings, teachers are decoupled from the process after recording and will be integrated only one more time later in the workflow for the quality control. The interface – see Fig. 3- supports the following functionality: notification per E-mail when new recordings are available, download of the streams separately as a ZIP file or side-by-side, automatic metadata of the lesson (room, name of teacher, name of module and lesson, time of recording), remote control of the recording devices and archiving functionality. Here also the first step in connection with the efficient subtitle generation is built in: the automated audio improvement. A good audio quality is not only essential for students but also for the speech-to-text service, hence we transmit the audio automatically to an external service and deliver already the improved audio via the recording management interface. The service we have chosen due to good experiences with achieved quality and with reasonable pricing is Auphonic [7]. The service is a little bit faster than real time, meaning that processing takes about the same time of the video length. Hence, the video is available with a small delay for further processing and publishing, which is on our site no problem and shouldn't be for most other universities either. Following the defined workflow, we also use this interface for downloading the recorded material for the post-processing step.

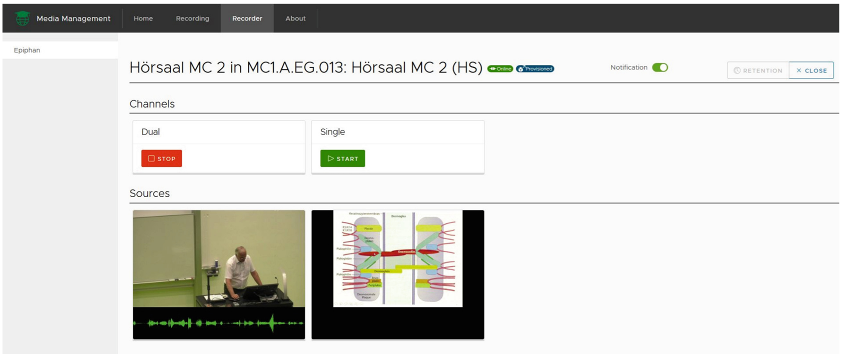

Fig. 3. Recording management interface for administrators with preview and remote control

Post Processing and Quality Check

In the post-production step we edit the recorded material. Due to the moderate number of recordings this step is currently done manually. We use Adobe Premiere in order to add a short introduction containing name of the module, title of the lesson and name of the teacher. Furthermore, we cut out sequences of bad quality, sometimes we add text bubbles when students ask questions without using microphones. Then we import the videos into our OpenCast server which renders two video qualities (Full HD and an SD). The video is published on the video portal where first only the teachers have access. The teacher performs a quality control of the ready-to-publish material. All wishes of the teacher will be taken into consideration – which may involve a re-editing and re-publishing - until they give their ok for publishing to the students.

Automated Audio Split, Speech-to-Text and Manual Subtitle Correction

When uploading the by the teacher approved material a special OpenCast workflow is utilized, which does not only generate the videos in two resolutions and publishes it on the portal and for our LMS Moodle, but also splits the audio and sends it to our speech-to-text service Amazon Transcribe [8]. Afterwards a manual correction step is inserted, the by a human approved subtitle file is then manually added to the published video. Since this takes a while - see next chapter for more details – the video is published automatically and immediately after processing the two resolutions, subtitles are made available later on.

Playout to Video Portal and LMS Moodle

The challenge for the playout software was to provide a user interface capable of playing two HD streams synchronically and to give students the flexibility for scaling the size of the two streams. In case the teacher shows something interesting on the whiteboard the video with the teacher can be zoomed and in case the information is only on the slides the video of the teacher can be switched off or made smaller. Furthermore, the player works in all standard web browsers without having to install any plug-ins and independently of the underlying operating system. Having all these requirements in mind we chose the Paella Player [6] which is now also part of the OpenCast open source software. We decided to offer two main possibilities to access the recorded lectures: 1) access via our LMS Moodle in order to access specific videos of specific modules, 2) access via a video portal where you have all recorded lectures in place ordered by courses and with a search function.

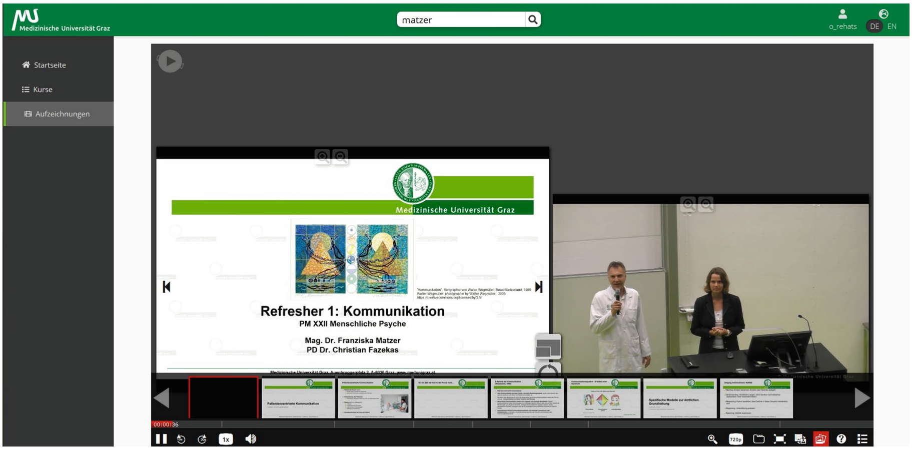

Fig. 4. VITAL video portal

In Fig. 4 the portal solution VITAL and the Paella Player is depicted. Next to the above described functions the player offers also a variety of speed (in case the teacher speaks to fast or too slow), a simple slide segmentation for navigation, the selection of video quality, different layouts, and – most important with the subject of the paper – also the provision of subtitles in multiple languages. The portal is also open source software based on the lecture interface from University of Halle [16] and allows access to all our recorded lectures (447 by April 2020). In connection with access rights we defined two groups, students and affiliates, which are assigned to the uploaded videos and grants access to the corresponding groups. Besides this of course access can be granted also to individuals or for the general public in case of open educational resources. The portal offers a hierarchical ordering by courses and provides a powerful search.

Integration into our learning management system Moodle is achieved via an embedded version of this player utilizing the standardized LTI (learning tools interoperability) [17] interface.

2.2 Usage of Tools for Speech-To-Text and Subtitle Editing

Based on the requirement to automatically produce a human readable text format which can be easily corrected by a human and integrated into our OpenCast platform we performed a small market research on speech-to-text services and tools which allow the manual correction of the produced WebVTT files.

Speech-to-Text Services

For the transcription service we had the requirement that it must produce a WebVTT file as an output. In this connection there exists a vast number of available free and liable to pay solutions. There is a vast number of speech-to-text services available, free and commercial ones. As a free service you can use e.g. YouTube which will automatically perform a speech-to-text conversion and also provides a WebVTT compatible editor for the subtitles, see Fig. 5. Since we have our own video portal and storage we did not go for YouTube, which requires the upload and storage of the files on their server. Since our files have up to 10 GB, and also due to copyright issues this was no feasible solution for us. Also, the speech-to-text quality was rather poor for German language.

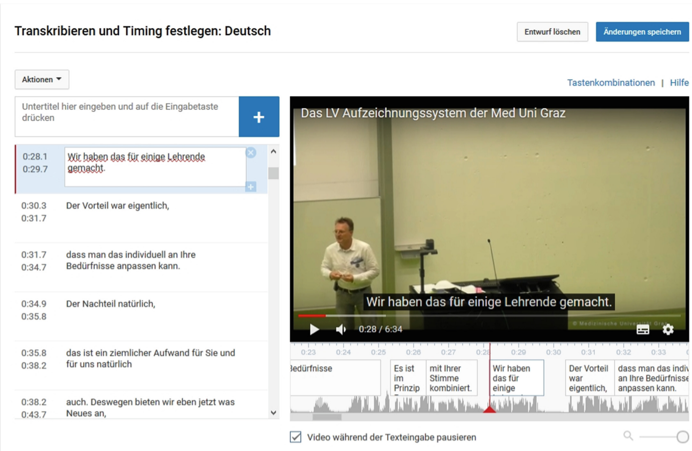

Fig. 5. YouTube closed caption interface

Next we tried out the commercial service AWS amazon transcribe [8]. Prices of the Amazon Transcription service for speech-to-text are reasonable even for low-budget universities having a moderate increase of video material. The service costs $ 0.00125 per second ($4.50 per hour), charged with an accuracy per second. In the first year, each month 60 min are free. For the transcription of the first 170 recorded lectures we paid less than $140. The service already delivers the required WebVTT format including the time codes, which can be directly imported into Open Cast or to other platforms / players, supporting subtitles such as YouTube. We finally decided to go for this commercial service, because it also offers a module specialized on medical language (amazon transcribe medical) and provides more than 30 languages. Since we are a medical university, this service fulfilled our requirements. If you do not require the medical vocabulary, the service is even cheaper ($0.0004 per second / $1.44 per hour).

WebVTT Editing Tools

What we have seen from the automatically generated transcripts so far: it is absolutely necessary to let a native speaking human proofread and correct the transcripts, at least when you plan to display them. In case you will only use them for searching, you might be satisfied with the delivered quality. Therefore, you will need a tool to process it efficiently.

For this purpose we again performed a small market research and found three solutions: the online tool VTT Creator [9], the subtitle editor from YouTube [10] and the very simple combination of a text editor (in our case Windows Edit) and our Video Portal VITAL.

VTT Creator offers a free, web based solution, which does not require any local installations. It has an integrated speech-to-text service, and offers a quite comfortable editor for correcting / adding subtitles, which is depicted in Fig. 6. The final file can be exported in WebVTT format for further usage.

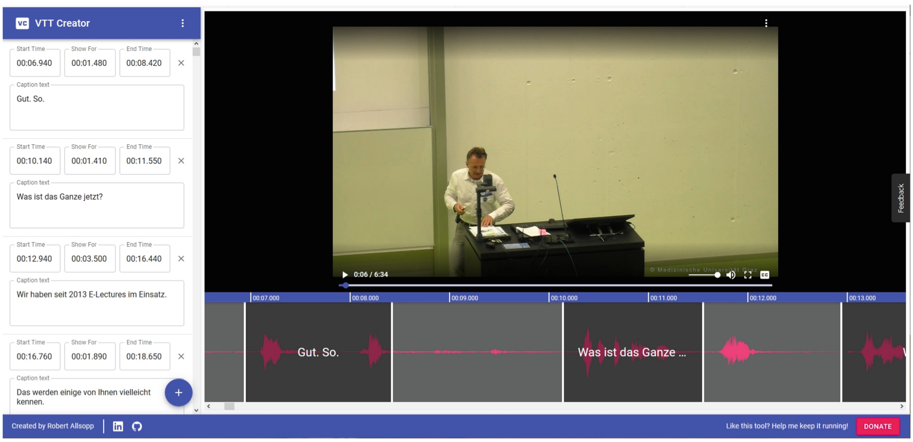

Fig. 6. VTT Creator online subtitle editor

For us the tool had several drawbacks: first the speech-to-text service is only available for English language (our main study language is German), second you have to upload the video files on the platform in order to take advantage of the service. Since our files have a size of up to 10 GB, the upload took a very long time, hence this solution was not feasible for us. We also measured the time it takes, to manually correct 10 min of a video transcript. All in all this took 77 min, also caused by the quite time consuming navigation within the user interface. In comparison to the finally by us chosen solution (see below) this takes more than 3 times longer.

YouTube also offers a subtitle service, which is depicted in Fig. 5. YouTube offers a speech-to-text service for a vast number of languages including German, however, the quality – especially in connection with medical terms – was poor. Again, an upload of the files is required, which is due to the size of the videos and in case of YouTube also copyright issues not feasible for us.

Next we tried to find free available offline WebVTT editors. In this connection we found Aegisub [11] and DivXLand [12]. Aegisub is a free open source tool, however, development was deceased in 2014, hence it does not support WebVTT format, which did not exist at that time. DivXLand offers only a Windows 8 version, but no Windows 10 version. The Windows 8 version does not smoothly work with Windows 10, so we skipped both options quickly.

Finally, the simplest solution turned out to be the best one. We used a simple text editor – in our case Windows edit, but any other ASCII editor would do it as well – in combination with our video portal VITAL (see Fig. 4). The person correcting the by AWS Amazon transcribe automatically created files opened them in a text editor and used the time codes in the file in order to navigate with the VITAL player to the positions in the video, which were not correctly transcribed and corrected the text directly in the WebVTT file. In order to better understand the spoken words a headset is highly recommended. With this process you have to take care only not to destroy the time code sections of the WebVTT file, hence only editing the text itself. However, since the format is very simple, this can be easily explained to the correcting person.

3 Experiences and Results

In general, we can say, the transcript quality significantly varied between a live recording (with students in the lecture room) and a recording made in an empty lecture room. We assume the main reason for this is the much higher background noise in a full lecture room made by the students. Hence, the manual correction effort in transcripts created from live recordings was higher.

The very best automatically generated transcript quality you receive by having a person recorded in an empty room with no background noise reading directly (and monotonously) from a script. Since this is a clear contradiction to doing a good presentation (it can be compared by a speaker who only reads from a paper and does not speak freely), we can state that technically it will be never possible to achieve 100% (or even close to 100%) accuracy with the automated speech-to-text process. Manual correction by humans will be always necessary in order to receive a 100% syntactically correct transcript.

3.1 Experiences

Before giving you some concrete numbers, we share our observations. First, we discovered, that the automatically generated transcript quality varies depending on the German dialect spoken. We are a university in Austria, and Austrian German varies in pronunciation and words from German German. Since Austria is with 8 millions inhabitants rather small in comparison to Germany (83 million), language transcription companies focus on German German, rather than the Austrian version. Since we have also some teachers from Germany, we could easily compare the quality of the transcript, and underline this hypothesis.

Second, even though German is our main language, many teachers use English words during their lessons for international technical terms or common words such as "review". Here the automatic transcription service totally failed, hence tried to replace the English words with a German word sounding similar. However, this was not a big surprise, since the automatic transcript software works on phonetics and it expects only German words in our case.

Third, we had several lessons where teachers showed videos in their lessons. Since most of those videos where in English, the transcription software failed due to expecting German language. However, even worse, in most of those lessons the teacher talks in parallel to the video giving additional explanations or translations, which made it even impossible for a human to understand all the words. The automatic transcription software completely failed.

Abbreviations – such as DNA, ALS – also result in a complete failure for the transcript software. Again, this is no surprise, since abbreviations are neither unambiguous nor can they be usually identified by humans to 100%. Here maybe extra, manually built, expert vocabulary will help, which is supported by main transcription services, also by the by us chosen AWS Amazon Transcribe. Of course this is connected to further human labor efforts.

Furthermore, we noticed, that connected words are not transcribed correctly. This is a special phenomenon with German language, where a lot of very long words based on the connection of basic words exist. For example, "qualitymanagement" is in German one word, and not two. However, this is only a minor issue since the transcript can be still understood despite not being fully grammatically correct.

Last but not least, punctuation marks are very often not put correctly in sentences. Our assumption is that in case a speaker makes a longer break at the end of the sentence, an end of sentence point is automatically set. Even though this should be good practice in a good speech, it does not happen frequently in our lecture talks, which have somehow more live character, e.g. interrupted by questions from students.

3.2 Concrete Numbers

During the manual correction process, we recorded the labor time necessary in order to achieve a syntactically correct transcript. These numbers give a rough estimation how much human labor time you have to invest:

- For 10 min video recorded in an empty lecture room (see above, higher transcript quality) about 26 min correction time are needed, which is a factor of about 1:2.6

- For a 10 min video recorded in a full lecture room (see above, lower transcript quality) about 32 min were needed, which corresponds to a factor of about 1:3.2
- For a 10 min video where the teacher simply reads down a script (see above, no free speaking – highest transcript quality) about 20 min are needed for manual correction, resulting in a factor of 1:2

4 Conclusions and Future Work

As the most important result of our work, we can state, even though the quality of the speech-to-text service varies significantly, doing it from scratch – without the automated transcripts, respectively – would require much more time! Because in this case you have to create also the WebVTT format with the time codes and you have no text basis to start with. Therefore, the semi-automatic process, chosen by us, turned out to be the most efficient way in terms of pricing and invested human labor efforts.

For the set-up of the entire Open Cast platform and in particular for the integration of adding semi-automatical subtitles in your existing technical workflow, we strongly recommend utilizing help from external experts. Regarding this, we made very good experiences with the non-profit organisation Elan e.V. [15], who provide professional help with the set-up and maintenance of the Open Cast platform for reasonable prices.

For all students, who do not have the language spoken in the recorded videos as their mother tongue, subtitles help to improve understanding the content. This is also true for places with high background noises (e.g. on the bus, in a restaurant) and in places where you cannot use audio because you would disturb other people. By adding subtitles, we expect to make the learning process more efficient for the students by giving them more options.

We plan to use the transcript also as a basis for scripts, which teachers (or students) may want to prepare for their lessons. Even though it still requires some work for formatting, a lot of time for writing is saved.

The transcript with time codes can be used for a frame-accurate search. Since the whole text is tagged with time codes the search can also be extended on the video content. Hence as a search result the exact position within the video can be found.

Last but not least, we plan to use the automatically generated transcripts to be translated in other languages used at our university, which is in our case English (German is the main language). The service [8], chosen by us, currently offers 32 languages. Once a speech transcript is received it can be easily translated into other languages. This will make our recorded lectures also accessible to students not capable of speaking the German language. However, this implies a manual quality assurance because you need a syntactically and semantically error-free text in order to receive reasonable results from the automatic translation software.

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Jewish Orthodox Female in Israel Higher Education A Test Case

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Abstract. The Jewish orthodox community is considered a secluded group within the Israeli people. In the Jewish orthodox community in Israel it is common that only the women study general studies such as mathematics and science while most of the men focus on religious studies. In such cases the women become the wage earners in their families. In order to fulfill their potential orthodox women are required to acquire higher education in the standard Academic institutes. Like many others of the younger generation they also are attracted to Software Engineering, Computer science and the digital high-tech world. Since they come from an environment that does not allow women and men to study together, a special program was established for them by an academic college allowing them to study in their own separated group for a degree in Software Engineering. They study the exact same curriculum as the secular mixed group but on a different campus. Since they come from a different background it is interesting to compare their achievements in studying to those of the mixed group. To do so and avoid the influence of their initial education the author decided to look into one 4th years course given both to the orthodox group and to a mixed group. The author, who was the lecturer of this course, for both the orthodox and mixed group, compares in this work the differences and similarities between the two groups, both by addressing their measurable success in the course and in attendance, active participation and more.

Keywords: Higher education · Diversity · Gender · Cultural adjustments

1 Introduction

Usually groups of people that do not study basic curricula, neither in their childhood nor in their adult life, come from developing countries or from small settlements far from the center. It is rare to find a group of people living in a developed country in central cities that chooses not to study core subjects as a matter of principle. In fact, most research on such groups is done in developing countries [1–4]. The Jewish orthodox community is the exception. This community is considered a secluded group within the Israeli people [5–7]. In 2018, 22% of all children that attended first grade in Israel belonged to the orthodox community, so this group is too large to ignore.

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Figure 1 show the increase in orthodox population in Israel in the period 2009 to 2019 with respect to the total population. The reason for this increase is that an average orthodox family has 6.9 children while the average Israeli family has 3.1 children.

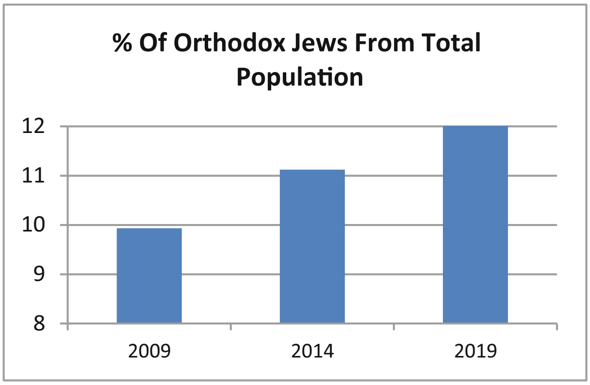

Fig. 1. The increase in orthodox population with respect to the total Israeli population (in %)

In the Jewish orthodox community in Israel it is common that only the women study general studies such as mathematics and science while most of the men focus on religious studies. In such cases the women become the wage earners in their families. Unlike the Amish community [8] that prevent themselves from all that is modern, the orthodox Jews use cars and electricity but most of them do not have television, internet or smartphones. Some have restricted versions of smartphones and limited access to pre-chosen websites on the net but no more than that.

2 Purpose

In order to support their families and obtain self-fulfillment orthodox women are required to acquire higher education in the standard Academic institutes. Like many others of the younger generation they also are attracted to Software Engineering, Computer science and the digital high-tech world.

Since they come from an environment that does not allow women and men to study together (or work closely together), they do not apply for one of the standard universities or colleges spread around Israel. Instead a special program was established for them by a College of Engineering allowing them to study in their own separated group for a degree in Software Engineering. The college is located in Jerusalem where the majority of orthodox Jews live, thus making it accessible for the students. They study the exact same curriculum as the secular mixed group but on a different campus. Since they come from a different background it is interesting to compare their achievements in studying to those of the mixed group, both with respect to the orthodox group they belong to and with respect to gender [9, 10].

3 Approach

To study the orthodox group and avoid the influence of their initial education the author decided to look into one 4th years course given both to the orthodox group and to a mixed group, in the same college. The author, who was the lecturer of this course, for both the orthodox and mixed group, compares in this work the differences and similarities between the two groups, not only by addressing their measurable success in the course but also in attendance, active participation and more.

It is important to note that prior to the first time the author taught the orthodox group, he a was given instructions to dress respectively to the lectures (no sleeveless shirt), avoid any contact with the students, stay on his site of the desk and not try to make small talk. More so, the 4th year of the degree is the first time that a male lecturer is allowed to teach the orthodox students, all the lectures and recitations in the first three years are given by female academic staff.

For four consecutive years, 2016–2019, a course in Digital Signal Processing was given to both the orthodox group and the mixed group. The syllabus of both courses was identical as where the course pre-requisitions and requirements. If the orthodox group was required to submit 70% of the home assignments, so was the mixed group, if the orthodox group had to take a midterm exam (weighting up to 20% of the final grade) so did the mixed group. The structure of the final exam was also identical (same subjects and same number of questions, and hopefully same level). During these 4 years the author measured the grades that the students obtained, the questions asked during class, the attendance (presence was not mandatory) and the willingness to submit homework assignments (it was not mandatory for the students to submit these assignments, but if they did and the grade was better than the final exam then 20% of the final grade was based on these assignments).

4 Actual Outcomes

Before addressing figures and numbers, the author finds it important to note that although he was given very strict instructions at the beginning of the course, the students themselves were very open. They approached their lecturer many times on his side of the desk and had no problem is generating small talk with him. This was true for all four years.

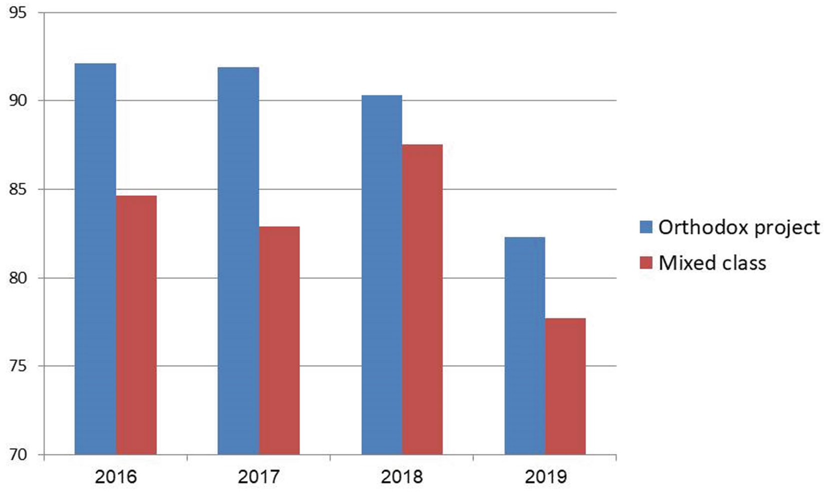

Fig. 2. The average grades in the final exams as a function of year for both orthodox (blue bars) and mixed (red bars) groups

The test groups contained 340 students in the mixed group (26.2% female students and 73.8% male students) and 101 students in the orthodox group (100% female students). The authors compared the grades of the two groups every year for 4 years as shown in Fig. 2. As can be seen in all 4 years the orthodox students obtained higher grades than the mixed group, in average 88.4 for the orthodox group and only 83.6 for the mixed group. The grades are also associated to the fact that the percent of failure reached as high as 33% for the mixed group (in 2017) but never crossed the 5% for the orthodox group. This is shown in Fig. 3.

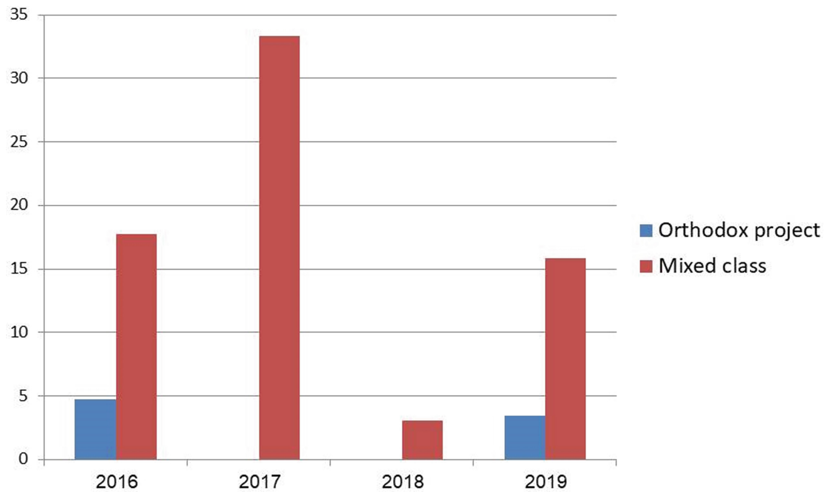

Fig. 3. The percentage of failure in the final exam (below 55) as a function of year for both orthodox (blue bars) and mixed (red bars) groups.

Another aspect that the author examined is the percentage of homework assignments handed-in. The assignments were not mandatory, but count as much as 20% of the final grade. Since submission was not mandatory, the actual amount of assignments handed-in could teach about students' commitment during the course and effort where they willing to put-in. As seen in Fig. 4, in two out of four years the numbers where similar in both groups but in the remaining two years the orthodox group handed-in many more assignments than the mixed group.

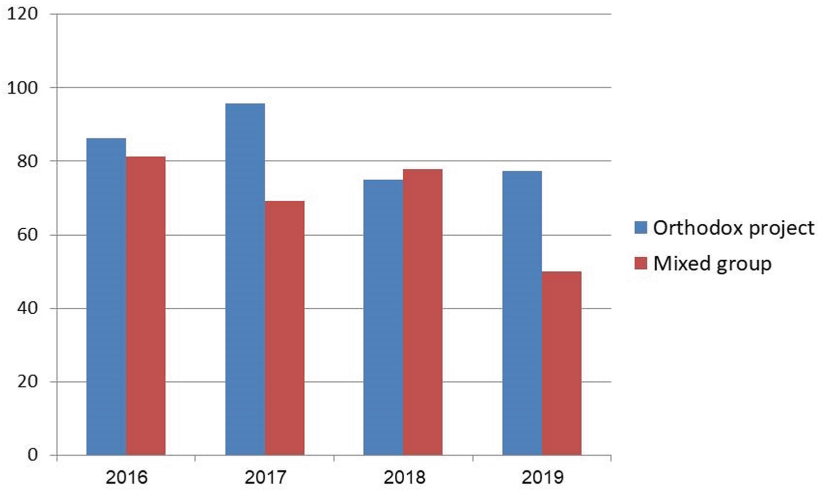

Fig. 4. The percentage of homework handed-in as a function of year for both orthodox (blue bars) and mixed (red bars) groups.

In fact, when adding up all four years the submission rates in the orthodox group reached 83.1% while the submission rates in the mixed group reached only and average of 68.8%. This indicates that it was more important for the orthodox students to study during the semester and not wait until the final exam to begin studying.

Finally the author examined how many of the students actually attended the first of the two possible final exams. In most academic institutes it is common to give students a second chance to correct the grade of their final exam; therefor they have two terms they can attend. Most students choose to attend the first term and only if they fail (or think they can do better given a second chance) they also attend the second exam. However, some of the students choose to skip the first term and attend only the second exam. This is of course risky as if they fail they do not have a chance to correct and they must repeat the course the following year. These students usually choose to skip the first exam either because they do not feel confident enough at the date of the first exam or they have many exams in a short period of time and they decide to take some in the first term and some in the second to ease the stress. In Fig. 5 we show the percentage of students that attended the first term in each year. As can be seen for the orthodox group the numbers were kept high at all four years (94% of the students attended the first exam from 2016 to 2019) while for the mixed group the percentage rose every year but even at its pick did not reach the value obtained by the orthodox group, in fact they average only 80.3% over the four years period. This means that while the orthodox students had a high sense of commitment from the beginning, the mixed group learnt the hard way that skipping the first exam (at least in this course) was not worthwhile.

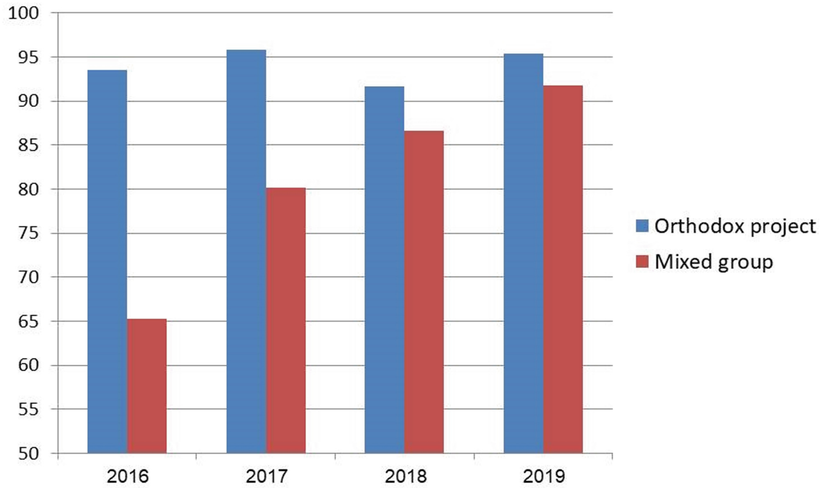

Fig. 5. The percentage of students that attended the first of two final exams as a function of year for both orthodox (blue bars) and mixed (red bars) groups

5 Conclusions

In conclusion, in this work the author examined the differences between a mixed group of students and a female-only Jewish orthodox group of students. The results obtained for one 4th year course taught for 4 consecutive years indicate that although the orthodox group came from a secluded environment and studied less core subjects in primary school and high school, their achievements in the final exam were better and they also showed more diligence during the semester. Addressing other courses given by different lecturers let to similar observations. One reasoning for these results is supported by former research indicating that minority groups tend to obtain better grades under the same conditions due to their will to stand-out. Another explanation could be related to the fact that in the orthodox community both men and women are taught from a young age that studying (mainly religion studies) is important for their success. A third explanation lays in the fact that orthodox women are expected to support their husband financially while he studies Tora and therefor they are dedicated to the process.

The personal connection with the students was as warm and personal as with any other group of students, regardless of their background, emphasizing that people that come from different environments can communicate without barriers and without attempting to change each other's views.

Due to this successful project it is suggested that other Academic Degrees and not just Software Engineering will be accessible to the orthodox female who wish to obtain higher education.

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The Development of the Multifunctional Digital Platform for Distance Learning and Evolvement "PsyTech" in the Era of Great Challenges

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Abstract. Nowadays higher education deals with the challenge to train competitive specialist that will be capable of changing both social and economic development of the society. Online learning plays a special role in this process. Modern technologies of remote access (project "Psychological technology PSY TECH") give the opportunity not only to improve the quality of knowledge and the efficiency of the educational process, but also to solve various social problems associated with higher education system. Distance learning surpasses traditional one when it comes to life-long learning, professional development or occupational retraining. Remote access to the information and computing services allow you to achieve effectiveness and flexibility in the process of learning and development in the modern higher education. Remote platforms allow you to unify and correctly build an individual training route by taking into account students' individual psychological characteristics, age, and special needs. Modern higher education institutes are searching for effective models of interaction with students, teachers and other employees. Along with the functions of socialization, reproduction and development of corporate culture, great importance is given to the socio-psychological development of the future specialists. The attention is also drawn to managing teachers' and administrative staff's stress. Thus, the proposed model is relevant and has significant practical importance.

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Keywords: PsyTech · Distance learning · Life-Long learning · Digital platform · Psychological platform

1 Context

In the time of big challenges distance learning is faced with such priority tasks as the introduction of modern educational technologies in the educational process and the development of skills for advanced interaction with digital resources in accordance with the internet capability. According to S. Posokhova, internet activity forms the ability to search and find the necessary information, analyze the obtained data, systemize the results, and efficiently prepare and present the relevant information [7].

In Olennikova's opinion, online education gives equal opportunities to all people regardless of their social status. It is available in any part of the country and abroad thus realizing human rights to education and information [6].

According to N. Almazova, the distance-learning environment is a system-organized set of data sharing tools, information resources, interaction protocols, hardware, software and methodological support that is mainly focused on meeting users' educational needs [1].

Rubtsova, A believes that distance learning is a good alternative for advanced training and professional retraining in the context of the life-long learning [8].

K. Zakharov notes that remote access to new IT services brings effectiveness and flexibility into the learning process. It ensures the development in the modern higher education by taking into account students' individual psychological characteristics, age, and special abilities [2].

O. Kunina considers distance learning to be a process operated with the educational procedures to be carried out with the use modern information and telecommunications technologies. The teacher and students are distanced from each other [2].

Granitz, N. notes that the educational process now actively introduces online group activities. There are special disciplines and classes that are aimed at making sustainable teams to achieve joint goals and solutions. This concerns not only competitive sports (eSports included) but also temporary or permanent groups formed for brainstorming, solving problems in business games, and laboratory work that requires teamwork and interaction over a certain number of sessions. Some disciplines contribute to the development of team skills that may be of interest to the future employers [3].

In these conditions, according to Kruglikov. V., is the issue of creating effective mechanisms for team play through various project technologies seems to be one of the most important aspects of educational activities [4].

The special requirements for disciplines and educational programs are motivated by the availability of distance learning methods and the increasing impact of network technologies on the educational process. New technologies may replace some usual practices but at the same time they have to keep up to the speed of social and educational development. The Internet has become the most important part of the modern educational process. It is the main tool for numerous educational and extracurricular projects in institutions [11]. The forms of interaction with the University in the Internet vary from the University's website to its social profile. Th University's electronic environment is not only a center of educational and scientific activities, but it also to attracts interested parties to the University, creates opportunities for collaborations and acquaintance with target audiences.

According to Tabolina, the growing level of digitalization increases the availability of mass research, including psychological research. It allows us to quickly receive and process large amounts of information opening up new opportunities for obtaining scientific results.

2 Purpose

The goal is to develop and test a multifunctional digital platform for distance learning and development "PsyTech" which ensures the effectiveness of professional education and students' self-actualization.

Research objectives:

1. To analyze the state of the problem of distance learning of students in the psychological and pedagogical literature;
2. To identify existing models for organizing distance learning for students in the professional education;
3. To develop and test the theoretical model for organizing distance learning for students in the Life Long Learning system;
4. To justify the criteria, indicators and levels of quality of professional education used to evaluate the effectiveness of the theoretical model of students' distance learning process;
5. To develop both scientific and practical recommendations regarding the regulatory, organizational, educational, methodological and personnel support for students' distance learning.

The following research methods were used to reach the research objectives:

1. Theoretical methods (the analysis and systematization of psycho-pedagogical researches and documents concerning education and methodology; the analysis of the requirements of the state standard GOST, pedagogical modeling, etc.).
2. Empirical methods (long-term observations, set of questions on a given topic, expert assessment and self- assessment, testing, interviews, etc.).
3. Summative and formative pedagogical experiment.
4. Mathematical and statistical methods of information processing (percentage distribution, ranking, histogram construction, etc.).

3 Approach

3.1 Key Projects of the Multifunctional Digital Platform

The multifunctional digital platform for distance learning and development "PsyTech" will implement several key projects:

First, to provide the psychological mediation (adaptation and assistance), as well as to monitor the environment and personal psychological potential development of participants in educational processes at the universities; Second, to develop and popularize digital tools for psychological counseling produced in Russia;

Third, to create a system for identification of gifted students, to organize the career guidance on in order to construct individual educational routes in accordance with the professions of the future and within the framework of trends of higher education (2 + 2 + 2);

Fourth, to replicate of best gamification practices in education;

Fifth, to implement projects and to replicate best practices of Digital brainware (a system of continuity of scholarly traditions, digitization of all available develop-ments, starting with the Soviet heritage) ver. 4.0.

3.2 The Tools' Structure

The psychological platform for distance learning and development of participants in the educational process of SPbPP is based on the methods of enabled observation and combines the experience of the world's web services in the field of social work, as well as Russian and author's developments in the field of remote counseling. This format assumes individual work with the participant, group forms of work are possible and are being tested (Table 1).

Table 1. The tools' structure in the psychological platform for distance learning and development of participants in the educational process of SPbPU Digital Psy Tech

The tool	Workflow form and the content description	Core distance technologies
Google classroom	Students/employees are invited to the psychologist's office by a unique code or are automatically imported from the university domain. A separate folder is created on the corresponding user's disk when a psychological course is being created. A client can submit the work for psychological analysis there	Modular technology Workshop technology Case technology
Microsoft Teams Within the framework of the university educational platform	Organizing psychological webinars with the shared screen; Collective work with files and online discussions, remote access to shared documents inside the channel; Personal and collective chats with text formatting access: Connecting reports from Power BI; An access to chat archive; Quick search in personal and collective chats, search by name or email address; Archiving chats; Recording psychological webcasts	Critical thinking development technology Project technology Game technology

(*continued*)

Table 1. (*continued*)

The tool	Workflow form and the content description	Core distance technologies
Moodle Within the framework of the university educational platform	Creating courses and modules that contain the information required for remote work; The ability to organize collaborative online meetings and publish messages for the entire team; planning of team activities; creating separate groups/rooms and chats; personal messaging and sharing files with colleagues; working together with documents	Developmental teaching technologies Health-saving technologies
Group B Vkontakte	Creating a digital footprint and forming groups based on social interaction. Useful content, express -consulting and online support for students, teachers and parents https://vk.com/digitalpsytech	Technologies of level differentiation Group technologies
Free psychological help forms	Google Forms	Information and communication technology
Telegram channel	https://t.me/joinchat/AAAAAFaCR7WZ8USt3hLgng	Integrated learning technology Pedagogy of collaboration
YouTube channel Digital Psy Tech	https://www.youtube.com/channel/UCJwyBvKHmoKClcg6QP9x-hg?view_as=subscriber	Critical thinking development technology
Psychodiagnostic methods, techniques and technologies	An Internet service that allows an individual researcher to create their own research (experiments) and get analytics based on research data	Project technology Game technology

3.3 Practical Activity

During the period from March to May 2020 in Digital Psy Tech "Psychological counseling centre" SPbPU received 546 applications (417-women and 129 men).

1. The start date is March 18, 2020
2. The last request date is May 25, 2020
3. The number of unique users/secondary and multiple requests is 456/90 people.
4. The number of requests (weekly) is 14 people.
5. The number of requests (monthly) is 167 people.
6. The total number of requests is 546 people.
7. The number of group classes is 38 people.

8. The number of videos is 31.
9. The average number of views is 50–100 people.

Quantitative data on the work of Digital Psy Tech (Fig. 1, Table 2).

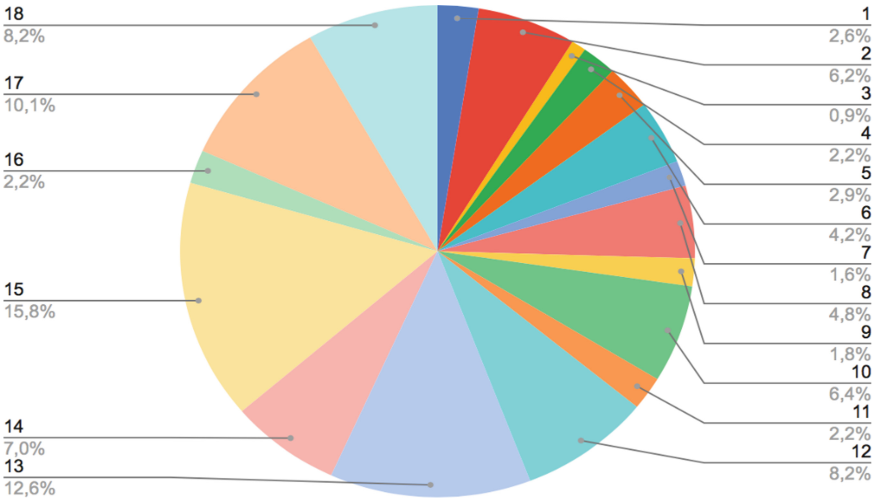

Fig. 1. Quantitative data on the work of Digital Psy Tech

Table 2. Quantitative data on the work of Digital Psy Tech

№	The subject of request	The number of requests
1	Low self-esteem	14
2	Grieving	34
3	Long-lasting mood disorder	5
4	Depression	12
5	Phobias	16
6	Post-traumatic stress disorder	23
7	Eating disorder	9
8	Addiction	26
9	Sex-role identification	10
10	Psychosomatic disease	35
11	Sexual issues	12
12	Loneliness	45
13	Conflicts (of any kind)	69
14	Relational concern (of any kind)	38
15	Troubles at home	86
16	Issues related to career and Professional development	12
17	Age and existential crisis	55
18	Reoccurring negative experience	45

4 Conclusions

First of all, the multifunctional digital platform for distance learning and development "PsyTech" is designed as a constantly developing IT environment with a set of tools for conducting psychological research at all levels. The process of online learning can be organized both independently and based on the deployment of information and educational environments. Modern technologies of artificial intelligence are planned to be used for big data analysis. The multifunctional digital platform for distance learning and development "PsyTech" will be helpful in several ways. On one hand, it will ensure the education availability taking into account the students' growing needs, the constantly changing requirements of the society, and the labor market. On the other hand, th platform will influence the flexibility of the educational system and its adaptation to a variety of social situations. Moreover, it will create conditions for academic students' mobility thus contributing to the professional mobility and social protection improvement.

Secondly, in this model psychological support is considered to be an integral activity of a practicing psychologist-teacher in the higher education system, the purpose of which is to unlock the professional and psychological potential of the individual. The teacher is striving to meet the needs for counseling as well as to create socio-psychological conditions for successful learning and psychological development of the student's personality.

Thirdly, it is important to note that the staff and teachers of Peter the Great SpbPU joined the consultations during the testing. This fact allows us to consider this model as all-inclusive in relation to the university staff. It is also possible to use this model to interact with target groups such as parents of applicants and applicants (with the consent of parents/caretakers).

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Poster: Technology "The Flipped Classroom" in the Study of Mathematics at the Technical University

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Abstract. Currently, modern educational technologies are actively used in the educational environment. However, the main method of training remains the traditional method. Therefore, we described and investigated the innovative technology of the flipped classroom in the study of mathematics and compared its effectiveness with traditional learning. As the subject of the research, strategies for using this technology for teaching second-year students mathematics are presented. The subject of study determined the purpose of the study, which is to describe implementation technology of the flipped classroom, focused on the study of the theory of functions of a complex variable. A pedagogical experiment was held at TPU, during which students who studied using the technology of the flipped classroom before a lecture on a specific topic made a summary of this lecture, the material of which was placed in the LMS MOODLE as a PDF file. Students were proposed to take notes of the lecture (if necessary, make notes about what was not clear, so that they could discuss it in class). At the same time, they should have left space in the notebook for proving theorems or for solving examples that demonstrate the use of theoretical material. A pedagogical experiment demonstrated that the use of technology of the flipped classroom improved student achievement. This technology allowed us to present the theoretical material in full. The flipped classroom technology allows you to spend as much time studying a topic as you need to understand it.

Keywords: Mathematics · Engineering education · The flipped classroom technology

1 Introduction

Currently, modern educational technologies are actively used in the educational environment. Among them are various interactive video presentations and video materials, electronic textbooks, blended learning [1], project-based learning and flipped

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classroom. However, the main method of training remains the traditional one. Therefore, in this article we will try to describe the innovative technology of flipped classroom in the application to the study of mathematics and compare its effectiveness with traditional learning. The flipped classroom technology was originally introduced into widespread in the United States. The essence of this technology is that the analysis and study of the material of the upcoming lecture takes place at home, and the evidence and theoretical points that are remained unclear to students examine in class. In other words, learning is the opposite: theoretical material is studied at home, while during the lectures are examined the proofs of theorems and in-depth tasks on the topic. Many teachers in different disciplines are interested in the flipped classroom technology, and various aspects of its application are reflected in various publications of both domestic and foreign scientists [2–5]. There are certain advantages of the flipped classroom technology, such as: comfortable working conditions, individualization of the educational trajectory. This technology makes students more independent and responsible, active and motivated. We also note such a positive aspect of this technology, as students who missed a class can always catch up with their friends, restoring the material using online lectures. We also note the drawback of this educational technology, such as not all students do their homework. In this case the student will not be understood and not be interested in the lesson [6].

As the subject of the research, strategies for using this technology for teaching mathematics to second-year students are presented. The subject of study determined the purpose of the study, which is to describe of implementation of the flipped classroom technology, focused on the study of the theory of functions of a complex variable (TFCV), and comparing the effectiveness of traditional teaching method and the technology of flipped classroom. In order to achieve this goal a number of research tasks have been defined:

1. To describe the flipped classroom technology as a type of blended learning technology;
2. To reveal the features of studying the topic theory of functions of a complex variable using the flipped classroom technology;
3. To determine the place of the flipped classroom technology in a math class;
4. To analyze the possibility of using this technology in the process of studying TFCV;
5. To develop a training module for the study of TFCV on the MOODLE platform within the flipped classroom technology.

In order to work on the goal.

1. We have studied and analyzed the available literature on the research problem.
2. Initial testing and final testing were performed for students of the control group (who studied TFCV using the flipped classroom technology) and students who studied this section of mathematics using the traditional method.
3. Statistical analysis of test results was performed.
4. A survey of students who studied using the flipped classroom technology was conducted.

2 The Place and the Role of Lectures in the Educational Process

The educational process in mathematics at the University is organized in the form of lectures and practical classes. Moreover, in Russian universities, the lecture is a very important component of the educational process. As a rule, up to half of the audit time is allocated for lectures. The leading role in the lecture usually belongs to the lecturer, who presents mainly theoretical material. Practical issues are less often considered at the lecture. One of the priority tasks of the teacher is to teach students to conduct logical reasoning, draw conclusions, and see patterns and cause-and-effect relationships, something that is so important for future engineers. The question of the place, role and form of lectures in the educational process is widely discussed and there is no clear answer to this question. Due to the rapid development of the Information and Communications Technology (ICT) and the emergence of new educational technologies, opponents of the lecture claim that the lecture as the leading form of study in higher education comes off the stage. Cherniavsky, A. G., gives the following arguments: "lecture teaches to passive perception of the opinions of others, inhibits independent thinking; lecture is giving off a taste for independent study; it is not possible to adjust the pace of the lecture for each student: some students have time to comprehend information, while others can only record the words of the lecturer mechanically; the lecturer usually lacks feedback during the lecture" [7], which does not allow to control the degree of assimilation of the material and make the necessary adjustments.

Of course, there is some truth in these remarks. In Russian universities, there is a tendency to reduce the hours of classroom work of students in the direction of increasing their self-developed. There is an acute problem of lack of classroom hours in teaching mathematics. After all, mathematics is the basic discipline for many Sciences, and it is very important to formulate clearly the basic concepts and definitions. Mathematical concepts are very difficult to remember and difficult to understand due to their abstraction. Very often, the lecture is devoted only to the formulation of the main definitions and theorems necessary for solving a certain range of problems. There is simply not enough time to prove theorems in which logical reasoning is carried out, conclusions are drawn, regularities and cause-and-effect relationships are seen. At the same time, every teacher remembers that the main pedagogical tasks that he must solve are: to awaken interest in the subject, to convince students of the practical value of the material being studied, to activate their mental activity.

Every year, starting from 2015, after the first semester, we conducted a survey of students studying in the specialty "mechanical engineering". We offered to indicate what difficulties and problems they encountered during the lectures during the first semester. There were no students who wrote about the absence of problems in the lectures. There were the most common problems reported by students, such as:

1. The difficulty of taking notes due to the fast pace of the lecturer's speech (85%).
2. The lack of visual illustrations of the many concepts (38%).
3. The difficulty of perception of theoretical material during a teacher's monologue without visual illustrations (54%).

4. It is difficult to correctly formulate a question for a teacher (32%).
5. There are not enough examples to illustrate the theoretical material (67%).
6. I don't have time to comprehend the new material (77%).

3 The Pedagogical Experiment in TPU

In order to eliminate these shortcomings, it was proposed to hold lectures in TPU using elements of innovative the flipped classroom technology since 2015. What is the essence of the flipped classroom method in teaching Mathematics at TPU?

It is impossible to solve mathematical problems if the theoretical material has not been studied and knowledge on the topic under study has not been obtained. Very often, practical classes on certain sections of mathematics in the educational process are held earlier than lectures on this section. In such cases, it turns out that students do not have sufficient theoretical knowledge necessary to solve practical problems. The teacher has to explain the theoretical material in practical classes, and then duplicate this material in the lecture. We suggest the following training scenario to avoid such situations:

1. The future lecture of the teacher is placed in the LMS MOODLE as a PDF file before the practical and lecture session on a specific topic. The student is invited to take notes of the lecture (if necessary, make notes in the material that he did not understand, to discuss in class). At the same time, you should leave space in the notebook for proving theorems or for solving an example that demonstrates the use of theoretical material. It is also suggested that students (if they wish) analyze the proof of the theorem themselves or solve an example using theoretical material, and during the lecture, demonstrate their own work, acting as a teacher.
   The time saved from taking notes at the lecture is directed to the proof of theorem, explanation of theoretical facts, problems, cooperation, interaction with pupils, application of knowledge and skills in the educational process. Practice has shown that this way the process of teaching at a lecture is rebuilt from a monologue of the teacher to a dialogue, in which the student plays an important role.
2. During the class, the main task of students becomes, based on the notes, to choose a theoretical material that can be used to solve a given mathematical problem. Then, together with the teacher, the students solve the tasks assigned.

4 Main Results

For 4 years, we conducted an experiment in which we proposed a mechanism for conducting lectures using elements of the flipped classroom technology, with students of different engineering specialties and on different courses. We have made conclusion:

1. The flipped classroom should not be introduced in the first year of training, as it is necessary that students are ready for it in terms of perception of information. In the first year, students begin to study disciplines related to the exact sciences, that is,

disciplines that use their own terminology. In mathematics, it is impossible to give a mathematical concept in your own, ordinary language. It should be clearly formulated and logically constructed. Higher mathematics, in contrast to school mathematics, contains a lot of theoretical facts and concepts that were not previously encountered by students. One cannot simply force to take notes of a lecture if the student does not understand many words in the definition, does not understand the notation. This can lead to many students not understanding the task and not being able to make a synopsis. Experience has shown that at least the first semester should be spent lecturing in a classic way, teaching students to terminology, abbreviations, basic designations, and the ability to hear and perceive basic mathematical concepts.

2. A prerequisite for working on the flipped classroom technology is to take notes of the lecture. Christian M. Marquardt: "When a person writes by hand, it not only increases the ability of his brain to remember what he writes, but also increases the level of representation and understanding of what he writes" [8]. The following facts support in favor of taking notes on lectures:

   - There are comparative studies [9–11] conducted among students who took notes on a laptop during the lecture, and those who wrote by hand. The results showed that those who wrote by hand remembered better and, most importantly, processed the information better. Those who took notes on a laptop, worse remembered the content of the lecture.
   - The Presence of the lecture notes in the notebook at the lecture allows the teacher to focus on proving theorems, explaining theoretical facts, and applying these facts to solve tasks.
   - The presence of a synopsis in the practical class will allow you to quickly and correctly find the information (formula or rule, theorem) necessary for solving mathematical problem. The lecture summary is checked at the beginning of each practical session. It should be noted that the new material for taking notes is possible only after discussing and taking notes of the previous material.

3. Students will not be motivated immediately. Recently, in the age of computer technology, students write very little by hand. Therefore, it is a very difficult task for them to devote an hour of time (no more) to taking notes on a lecture, because they are not used to doing this. At the initial stage, they can be motivated by entering the presence of the synopsis in the student's rating list (this is a bonus for such work as writing). However, after the second or third practical session, students understand the advantages of having a lecture material in practice. Since this saves time to find a method for solving problems. After all, the lectures offer basic material that allows you to solve problems on this topic.

We used the flipped classroom technology in the 3rd semester. At this time, all students of TPU study the TFCV section. 24 h are allocated for lectures on this section and 24 h are provided for practical classes, 50 h are allocated for independent training. According to the work program, this section includes the following topics: Complex numbers, sequences of complex numbers, functions of a complex variable (FCV), continuity and differentiability of the FCV, integration of the FCV, series in the complex domain, singular points, residues, and the application of the theory of residues in solving practical problems. The flipped classroom technology allows you to solve questions about how to give such a large volume of theoretical material in time for lectures and how to teach how to solve problems in the proposed time in the classroom. This section is completely new in contrast to other sections of mathematics that were at least partially encountered in the school mathematics course. In order for the inverted class model to be implemented in the educational process of teaching mathematics, the following work was necessary. Firstly, it was necessary to rewrite the curriculum and divide the available material so that the lecture that you need to take notes can be analyzed in detail with evidence and examples in the classroom. Secondly, it is necessary that it contains all the facts necessary to solve a certain range of tasks offered in practical classes and in individual homework. Thirdly, create a system for evaluating: independent work at home; collective and individual work in the classroom; individual work at a lecture (if the student wanted to be a teacher and prove a theorem at a lecture). Finally, master the tools for developing presentations and placing them in the LMS. Our experience has shown that the selection of material for a lecture and its volume is important in the process of teaching mathematics. When selecting material for the lecture we proceeded from the following principles:

1. Each lecture should contain a sufficient amount of material that can be analyzed in one class session, in which you can explain the proposed definitions, prove the given theorems, and solve examples that illustrate the presented material.
2. The lectures should present the facts that can be applied to solve practical tasks or those facts that prove or explain very important theorems.
3. For each lecture, a practical lesson should be worked out, tasks are selected in such a way that when solving them, it was necessary to use already known theoretical material.
4. Lecture notes should take no more than 1 h.

5 Statistical Analysis of the Results of the Pedagogical Experiment of TPU

This article presents the results of an experiment conducted in the 2018–2019 academic year. The essence of the experiment is to compare achievement of students enrolled in the flipped classroom technology (4 groups of students enrolled in the specialty "mechanical engineering" with the achievements of students trained traditionally, 4 groups of students of engineering school of energy). The results of the pedagogical experiment of TPU are presented in Table 1.

Table 1. Results of the pedagogical experiment of TPU

	The sample mean	The sample variance	The sample standard deviation	The number of students
Initial testing				
The flipped classroom technology	$\bar{x} = 6.94$	$D_x = 7.58$	2.75	$n = 64$
Traditional training	$\bar{y} = 8.71$	$D_y = 9.14$	3.02	$m = 55$
Intermediate testing				
The flipped classroom technology	$\bar{x} = 6.79$	$D_x = 5.64$	2.38	$n = 58$
Traditional training	$\bar{y} = 7.76$	$D_y = 7.66$	2.77	$m = 93$

Let's test the hypothesis that the average score of groups who studied using the flipped classroom technology and traditional one differed significantly during the initial testing. To do this, at the significance level of 0.05, we will check the null hypothesis H_0: M[X] = M[Y] about the equality of mathematical expectations of test scores with the competing hypothesis $H1$: M[X] $\neq$ M[Y] [12], where X is the entire assembly of test scores of students who studied using the flipped classroom technology, and Y the entire assembly of test scores of students who studied using the traditional method. The sample sizes are equal accordingly: n = 64, m = 55. Observed value of the criterion is $Z = \frac{\bar{x}-\bar{y}}{\sqrt{\frac{D_X}{n}+\frac{D_Y}{m}}} = -3.28$. From the table of values of the Laplace function we find the auxiliary point z by the formula $\Phi(z) = \frac{1-\alpha}{2} = 0.475$. Then z = 1.96. Since $|Z| > z$, then we reject the null hypothesis, that is, the average scores of students who studied in different technologies differ significantly. Similar calculations are performed for the data of the intermediate testing. In this case, $Z = -1.4$, and the auxiliary value of z is the same. Since $|Z| < z$, we accept the null hypothesis, that is, the average scores of students who studied in different technologies differ insignificantly. If before the experiment the average score of the control group (students who studied using the traditional method) was significantly higher than the average score of the experimental group, then after the experiment the average scores were approximately equal. Let's see how the experiment affected the average score of students who studied using the flipped classroom technology. To do this, let's compare the sample average of initial and intermediate testing of students who studied using the flipped classroom technology. In this case Z = 0.32, and the auxiliary value of z is the same. Since $|Z| < z$, there is no reason to reject the null hypothesis, that is, the average scores of students before and after the pedagogical experiment were approximately the same. As for the control group, it can be seen that after studying the topic of TFCV, the average score of students decreased. Thus, the pedagogical experiment demonstrated that the use of the flipped classroom technology has improved the achievements of students in the study of such a complex topic as TFCV.

6 Conclusion

Based on the above, we conclude that the flipped classroom technology allows you to spend just as much time studying the topic as you need to understand it. A student at any time at their own pace can make a summary of the lecture (before the beginning of the lecture or practical class, which will use the materials presented in the lecture), look at the educational literature, make notes in the material that is not clear, in order to discuss it already in the classroom. In addition, the student can solve the proposed problem using the stated theory or make questions on the solution of the problem, if he could not solve this problem.

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Ethical Attitudes Among Engineering Students: Some Preliminary Insights

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Abstract. There is a rising interest in engineering ethics education. As research in this field shows, the most common reasons for that are rather formal implying to satisfaction of accreditation requirements and complying with the recommendations of a disciplinary professional association. Resistance to notions such as professional judgment and the absence of any substantial reference to engineering ethics in general conversations about educational decision-making and governance is also witnessed. Teaching engineering ethics to students could be considered a crucial course that builds the necessary basis so that engineering students can develop better, i.e. more sustainable and responsible, technological solutions to societal challenges. At the same time, we do not have much information or many studies about the actual beliefs or ethics attitudes of future engineers and methods of influencing their attitudes concerning challenges related to sustainable development. The purpose of the study is twofold, we 1) explore the ethics and sustainability attitudes of engineering students and 2) make preliminary proposals for the betterment of engineering ethics teaching. Our study shows that shaping attitudes and behavioural intention towards certain values, for example towards sustainability, needs clearer manifestation in societies in general, as well as in professional communities.

Keywords: Engineering ethics · Teaching engineering ethics · Ethics attitudes · Sustainable development

1 Introduction

The beginning of the 21 century has shown that engineers need to have well developed soft skills to cope with the situations of a new kind. For example, the United Nations (UN) Sustainable Development Goals (SDGs) expect engineers to be aware of challenges in various fields, where problems and possible solutions are linked to technology development. Also, globalization has brought new types of problems to all countries, to name the virus Covid-19 specifically, and fighting with new challenges expects broader and more responsible approaches from all professionals. All this creates a huge demand for a new form of engineering education because just giving better technology education might not lead to finding responsible and problem-solving solutions.

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It is expected that the engineering education of the future has a broader basis and involves more courses intended to develop the requested soft skills so that the students learn to better handle present and coming societal challenges utilizing technological developments. For example, what to do in cases when technology companies and engineers face a dilemma to prefer human lives or profit (e.g. the extraordinary legal action taken against a company producing Covid-19 tests which not the only example of some individuals putting profits before people [1]). Cultivating students to become proficient in reasoning about ethical issues and practices is thus becoming more and more important in Engineering in the context of worldwide scandals involving unethical and illegal practices in professional communities.

The 17 SDGs are “an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests” [2]. There is an expectation that future generations can face and provide solutions to those challenges.

2 Problem Formulation

There is a rising interest in engineering ethics education (e.g. [3, 4]), but the most common reasons for that are rather formal implying to satisfaction of accreditation requirements, and complying with the recommendations of a disciplinary professional association [5]. Resistance to notions such as professional judgment and the absence of any substantial reference to engineering ethics in general conversations about educational decision-making and governance are also witnessed [5]. At the same time, we do not have much information or many studies [6, 7] about the actual beliefs or ethics attitudes of future engineers and methods of influencing their attitudes concerning challenges related to the SDGs.

Teaching engineering ethics to students could be considered a basic course intended to build a necessary basis so that engineering students can develop better, i.e. more sustainable and responsible, technological solutions to societal challenges. As ethical behavior has become a part of the professional identity and practice of engineers [8, 9], an important goal of teaching ethics to engineering students is to enhance their ability to make well-reasoned ethical decisions in their engineering practice: a goal in line with the stated ethical codes of professional engineering organizations [10]. Also, a well-structured, integrated, and innovative pedagogy for teaching ethics has an impact on the students’ attainment of ethics education objectives and their attitude towards engineering ethics [6].

Thus, there seems to be a gap between contemporary global goals expressed in SDGs, established value sets expected from engineering practitioners, and expressed in engineering codes of ethics and actual values of students. Codes of ethics emphasize on the fields of safeguarding the quality of life and protect the public interest as well as consumers' interests, for example in the Code of Conduct for European Chartered Engineers [11] or health, safety and welfare of the public, for example in the NSPE Code of Ethics for Engineers [12] and not so much on sustainability or SDGs.

A general question arises from here: should universities provide a professional training which prepares future professionals in accordance with the values and attitudes agreed on among professional communities and expressed in codes and value statements (classical professional training) or should universities prepare future professionals according to the future needs even if the value set might not coincide with agreed professional engineering ethics statements expressed in codes? In other words, should the engineering ethics teaching be compliance-based or should it pay more attention to moral reasoning and justification?

Even though it is clear, that updating codes of engineering ethics is a long-term undertaking. However, at the same time, all students are also citizens and expected to act and behave responsibly. SDGs are not only goals for professionals but everyone.

Against this background, the purpose of the present ongoing study is twofold: 1) to get a better understanding of factors influencing engineering students' ethical decision-making to improve the methodology and content of ethics courses, and 2) to explore the link between ethics attitudes and SDGs. With this study we want to develop insight into the development of ethical attitudes among engineering students, as previous studies in other professional fields [13, 14] have demonstrated mixed results about the effect of ethics courses on developing ethical reasoning skills of students.

3 Method

To reach our overall research purpose we took advantage of a survey design. In the following, the steps taken are outlined.

We replicated the study by Riemenschneider et al. [15] that investigated ethical decision-making of students in an academic setting. This study was grounded in the Theory of Planned Behavior (TPB), and studied the influence of attitude, subjective norm, perceived behavioral control, moral judgment, and perceived importance of an ethical issue on a student's behavioral intention. We used the same methodology but designed cases related to compliance and responsibility to make them fit our research purpose.

Two cases were developed to estimate the ethical decision-making of students (see Table 1). The first case is related to norms of data protection (GDPR), and the second case tested a broader attitude towards sustainability-related responsibility[1]. Scenarios were developed considering the relevance of students' expected experiences. Both scenarios were followed by 15 specific measurement items for latent constructs of behavioral intention (1 item), attitude (3 items), subjective norms (1 item), perceived behavioral control (3 items), moral judgment (4 items), perceived importance (3 items) using seven-point rating scale with assigned values for numbers 1 and 7 (see Table 1).

Reliability scores (Cronbach's alpha) for constructs with two or more items were calculated for both scenarios (see Table 3). Cronbach's alpha of most constructs was close to 0,8 as recommended reliability standard for applied research by Nunnally, and two scales had modest reliability of over 0,7 which is also considered acceptable [16].

[1] SDGs 10 *Reduced Inequalities*, and 3 *Good Health and Well-Being.*

The survey was conducted among engineering students from the Tallinn University of Technology (TUT). TUT is the only university in Estonia giving engineering education. Engineering ethics courses are not compulsory to all engineering students and teaching of ethics-related courses depends on curricula. In the spring semester of 2020, ethics-related courses were taught to students from the curricula of information technology (IT), civil engineering (CE), and architecture. For the IT students, attending the ethics course was voluntary while for civil engineers it was compulsory. The target group of our study were all participants of ethics courses who were enrolled in the courses via TUT's CMS Moodle.

Altogether 96 students were invited to participate in the survey (39 from IT and 57 CE Department). Data were collected via an online survey between 7–20 May 2020. We received 32 responses (of which 6 came from female students): 16 responses from IT students and 16 from engineering students, which meant a response rate of 33%. The students were aged between 19–29 years (90.6% of them were between 19–23 years old). 16 respondents were 1^{st}-year students, eight were 2^{nd} and the remaining eight students were 3^{rd}-year students.

Data were analyzed using SPSS vers.26.0. We used means, standard deviation, and frequencies to illustrate the distribution of responses. Pearson correlation coefficients, pairwise Student's t-test, and OLS regression analysis were performed to estimate relationships between variables.

4 Results

Firstly, we analyzed the distribution of responses concerning behavioral intention as well as other latent variables used to measure ethical decision-making. In Fig. 1, one can see that the answers from 32 respondents to Case 1 were distributed rather uniformly - on a scale from 1 to 7 where smaller values indicated unethical and higher values ethical behavior.

Regarding behavioral intention in Case 2, a rather similar pattern of responses emerged (see Fig. 2) with respondents choosing all possible answers in a way that a clear trend in favor of either ethical or unethical behavioral intention cannot be determined.

In Table 2, the means, standard deviations, and statistics describing the results of the T-test we used to compare the components of ethical decision-making are presented. We can see that ethical decision-making regarding behavioral intention, ethics attitude and subjective norms (or personal normative beliefs concerning the moral obligation to perform an act) are rated quite similar in two scenarios with mean values around 3.93–4.59 scale points and rather large standard deviation indicating no clear positive or negative attitude towards ethical issues. In other words, what concerns 1) behavioral intent (i.e. the intention that shows the motivation behind behavior and that indicates the amount of effort one is willing to exert to perform that behavior), 2) attitude towards the topics (i.e. the degree how favorably or unfavorably evaluates the behavior) and 3) subjective norm or how morally one would feel obligated to take corrective action, there is considerable variance in ethical decision-making of students.

Table 1. Scenarios of ethical decision-making and instrument items.

Scenarios (Case 1, Case 2) and instrument items (rating scale in parenthesis)
Case 1. Jan is a student and a part-time worker in a small IT company that has a contract with the national health board to do analyses on big data collected and stored by the board. His father works at the university in the field of biomedical informatics. Because of a fast-spreading virus, the health board receives a lot of new information and asks the company to analyse data for the board. Jan tells about the new task at home and the father asks to share the results with him to test his scientific ideas in fighting with the virus. Jan sees the fathers' request as an input to fight with the virus and decides to copy the data and hand them over to his father
Case 2. Adele is an engineering student and her professor gives her the assignment to solve a problem of accessibility to specific public services within strictly given conditions. Adele sees that initial parameters given to her do not allow her to design a solution that would take into account the needs of people with specific disabilities. She tells about her concern to a friend who is studying the same course and asks her opinion to write to the professor and to change initial conditions. Her friend sees that unnecessary as it is just a course assignment and there is no need to complicate the situation. Adele agrees with her friend and does nothing
Behavioural intention: If you were Jan, what is the probability you would pass the data to your father? (highly probable/1..7/highly improbable) **Attitude**: Jan's decision to copy data and results of analyses and give them to his father was (good/1..7/bad, right/1..7/wrong, acceptable/1..7/unacceptable) **Subjective norms**: How morally obligated would you feel to take corrective action in this case and tell the IT company that you have copied data and results of the analysis? (no obligation/1..7/strong obligation) **Perceived behavioral control**: Delivering the copied data and results of the analysis to my father would be (easy/1..7/difficult, simple/1..7/complicated, under my control/1..7/out of my control) **Moral Judgement**: The act of copying data directly from the company's database is wrong (4 statements) (strongly agree/1..7/disagree) **Perceived importance**: Jan's decision to copy the data from the company's database was a (fundamental issue/1..7/trivial issue, issue of considerable concern/1..7/issue of no concern, highly important issue/1..7/insignificant issue)

Also, the mean values of all these three constructs are not significantly different from each other with $\alpha \leq 0.05$.

However, perceived behavioral control, moral judgment, and perceived importance of ethical topics are evaluated differently in two scenarios. It appeared that data protection issue of scenario 1 was rated more important and fundamental (higher perceived importance) in comparison with scenario 2 where the interests of disabled people when solving a problem of accessibility as homework was not paid attention to (that ethical topic was rated as of medium importance). Also, moral judgment (the way person reasons when faced with an ethical decision) was significantly stronger in scenario 1 compared to scenario 2. The perceived behavioral control was somewhat stronger in the data protection scenario as compared to scenario 2, where not writing to the professor would be for students more easy, simple, and under their control.

In both ethical decision-making scenarios, the respondents' major (IT vs CE) as well as whether s/he is 1st or 2nd or 3rd-year student did not affect the 6 ethics-related

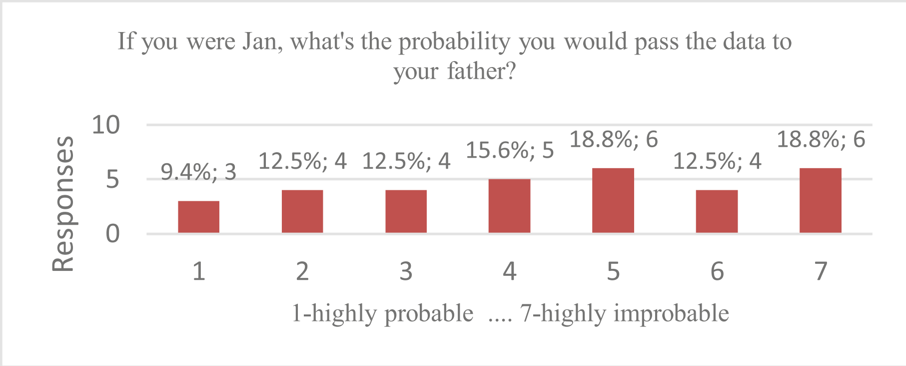

Fig. 1. Case 1- distribution of responses of ethical behavioral intention.

variables we investigated. Respondents age was positively correlated to ethical behavioural intent ($r = 0.38$, $p = 0.03$), ethical attitude ($r = 0.43$, $p = 0.015$) and perceived importance ($r = 0.31$, $p = 0 .087$) in scenario 2 indicating that older students conceptualize ethical issues not related to clear norms (e.g. protecting disabled or disadvantaged groups) differently compared to younger students.

Looking at correlations between behavioural intention and other latent ethical constructs (see Table 3) we can see that behavioural intention is related a bit more strongly with ethical attitude in the first scenario (data protection in the context of professional conduct) compared. to scenario 2 (suggesting to modify the assignment in a way it takes into account also disabled groups). Interestingly it appeared that subjective norm is related to behavioural intention in 1^{st} scenario but not in 2^{nd} scenario; and perceived importance of ethical topics is not correlated to behavioral intention in scenario 1 but is strongly correlated with behavioral intention in scenario 2. It means that the more Adele`s decision not to inform the professor was seen as an unimportant and trivial issue, the higher was the probability of not contacting the professor and suggesting a modification of assignment towards a more responsible one.

Regarding subjective ethical norm, we found that stronger felt obligation to take corrective action in scenario 1 was related to lesser intent of unethical behavior (but in homework assignment situation subjective norms were not related to behavioral intention).

Analyzing correlations between latent constructs in two scenarios it appeared that subjective moral norm, perceived behavioral control and moral judgments were positively strongly correlations in scenario 1 and 2 ($0.67 \leq r \geq 0.61$, $p < 0.001$) whereas the correlation between behavioral intentions in scenario 1 and 2 was weak ($r = 0.3$ $p = 0.064$). The latter indicates that not all respondents with more ethical behavior intention in the first scenario had also more ethical behavioral intention in the second scenario. The perceived importance of the ethical issue in scenario 1 was weakly correlated with the perceived importance of the issue in scenario 2 ($r = 0.32$ $p = 0.083$).

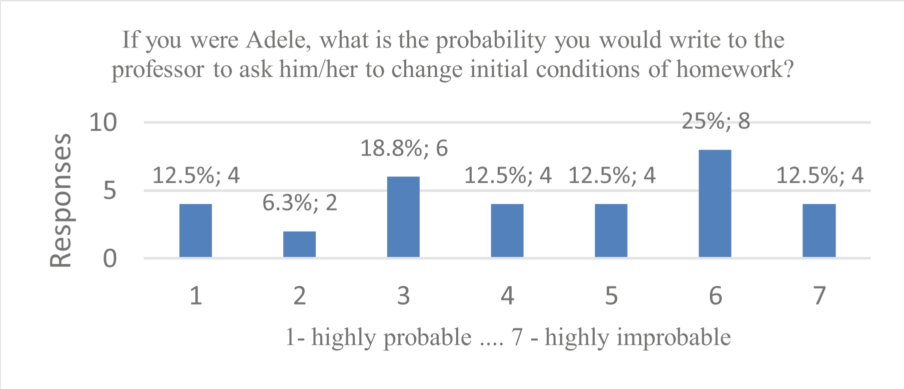

Fig. 2. Case 2, distribution of responses of ethical behavior intention.

Table 2. Descriptive statistics and results of paired-samples t-test.

Latent construct	Case 1		Case 2		Comparing means	
	Mean	Std. Dev	Mean	Std. Dev	t-stat	Sig. (2-tailed)
Behavioral intention	4,34	1,96	4,31	1,96	0,055	0,956
Attitude	4,59	1,86	3,93	1,20	1,922	0,064
Subjective norm	4,59	1,86	4,03	1,94	1,890	0,068
Perceived behavioral control	3,48	1,40	2,53	1,27	4,944	0,001
Moral judgement	2,20	1,29	3,09	1,21	4,536	0,001
Perceived importance	3,09	1,46	4,15	1,56	3,354	0,002

Table 3. Correlations between ethical decision-making constructs and reliability indices.

Latent construct	Behavioral intention		Reliability	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Attitude	.72**	–.60**	0.86	0.74
Subjective norm	.63**	–.28		
Perceived behavioral control	.36*	–.53**	0.77	0.73
Moral judgement	–.47**	.48**	0.86	0.81
Perceived importance	–.034	.63**	0.78	0.89

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

5 Conclusion

We draw the following conclusions based on the survey results presented above.

Firstly, younger students have not developed their own ethics value system and they need stronger support by clearly stated norms. If they perceive the importance of ethical issues and the intention is supported by the norm, they are more intended to behave accordingly. Younger students might incline to more sustainable social behaviour but they need to have clearly stated behavioural expectations to act.

Secondly, skills to conceptualize ethical issues, not to expect clear norms, and behave on the basis of excogitated values comes with age and experience. When planning workplace practice as a part of the professional preparation of younger generations, ethics issues and their analysis should be included in the agenda to give students the opportunities to identify themselves with practitioners and to familiarize the students with situations of ethical decision-making.

Thirdly, clearly stated and concrete problems (in our case data protection) are perceived to be more important than issues which might have bigger importance on a global scale (in our case taking responsibility in reducing inequalities) but they do not have a concrete form and are not clearly made explicit in current social debates.

Thus, in the context of engineering ethics education, we can conclude, that clearly stated professional norms should be included in the professional preparation of younger generations. They are also important in shaping students' attitudes towards ethical behaviour. If engineers want to develop stronger attitudes towards sustainability, they need to include respective norms in their codes of ethics as well. The balance between compliance and norms, and moral reasoning and justification should be found in ethics teaching in all universities.

As regards the limitations of our study, despite continuous reminders, we only managed to get a lower response rate than originally expected. The main reason was the pandemic of coronavirus and distance learning not allowing direct communication with students and consequentially the weaker bound to respond. Thus the small sample did not allow us to make robust conclusions or provide conclusive solutions but rather they gave us promising initial insight for further studies. Yet, we consider the presented study as a relevant one to addressing the problems of shaping the ethics attitudes of engineering students towards professional responsibility and sustainability.

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Engineering Students Mobility: Intercultural Barriers to Achieving Intercultural Competences

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Abstract. Intercultural competences play an increasingly important role in engineering. Mobility of university students enables obtaining benefits from different cultural and lingual environments, gaining cross-cultural experiences, as well as learning languages, habits and customs of host countries. However, besides the evident advantages, international exchange is surrounded by some concomitant problems. This research aims to enhance intercultural competences of engineering student by overcoming the main intercultural barriers recognised during the case study devoted to the international exchange. For this end, some educational modules are revised, the reasons of inactivity of certain groups of students are found out, and several steps are offered to improve mobility outcomes. The paper may help students guide their own education and suggests useful references for university staff in improving their current curricula.

Keywords: Engineering education · Intercultural competences · International exchange · Academic mobility

1 Introduction

Day by day, intercultural competences play an increasingly important role, and multinational organizations are becoming more and more competitive in the global marketplace. This largely concerns engineering activity conducted in international teams on multidisciplinary engineering problems. Departments consisting of individuals of different cultures and nationalities become the common parts of enterprises and companies worldwide. Both in business and in education the number of people moved from their homelands grow significantly. It was estimated in [1] that by 2017, more than 200 million people lived abroad, including above five million of foreign students. This demonstrates that modern humans are likely to work and study among people with different cultural backgrounds.

Multicultural environment have many benefits. Diversified skills and experiences of the collective members increase creativity and innovation, interaction styles in different cultures, and flexibility in resolving communication misunderstandings. Intercultural competence contributes to the professional competitiveness, knowledge sharing, foreign language proficiency, and facilitation in obtaining professional experiences among culturally different communities [2, 3]. Intercultural competence advantages include

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nurturing professionals of an international range, immersing specialists in other countries, and enriching their skill in unfamiliar cultures. Transnational movement of talents facilitates the mastery in people interconnection, expands professional networking, and shares interethnic perspectives [4].

However, intercultural diversity can call conflicts and other problematic issues; therefore, international exchange is to be purposeful and well organized. Within this context, the best method for enabling international exchange is mobility of university students in order to prepare them for future careers [5]. This makes the university attractive to a wide variety of youngsters. Inter-institutional exchange aims at equipping students with skills and knowledge needed for succeeding in globalisation and in obtaining benefits from diverse environments and gaining cross-cultural experiences along with learning languages, customs, and habits of host countries. As greater numbers of international students enter the university, intercultural competence becomes more and more likable thus contributing to awareness, knowledge, and international exchange.

Two categories of the student exchange are commonly distinguished: short-term study (usually, one or two semesters) and long-term staying to study for a longer period and preparing for a degree.

Since 2014, the Erasmus+ Programme [6] supports international exchange between higher educational institutions in EU countries, which helps students in studying abroad for short periods, semesters, or even academic years. This project endorses undergraduate and graduate levels, at which completion of the free-year baccalaureate serves as a pre-requisite for admission to the magistracy. Erasmus + opens learning and training opportunities with appropriate services ensured by academicians and staff. Some successful methodologies for skill acquisition and knowledge assessment criteria along with agreed curricula and integrated study programmes are developed in the frame of the Programme (ECHE) [7, 8].

In addition to Erasmus+, several other programs support worldwide learner's mobility, for example, Erasmus + International Credit Mobility Programme (ECP), aimed at strengthening cooperation between EU universities and institutions from non-EU countries.

Many virtues of student mobility are announced in related researches. Thanks to international competitiveness, the graduates easily make next steps in their career. In five years after graduation, the unemployment level of youth who took part in academic mobility is 23% lower than that of those who did not participate in the Programme. It strengthens occupational capabilities of graduates after completing their studies and beginning a permanent job in a native country or abroad [9, 10]. Particularly, from 25 to 55% foreign graduates annually find their job in Estonia as a host country.

Nevertheless, despite the general understanding and agreement among academicians about the benefits of international exchange, several barriers prevent effective usage of these opportunities. Recent researches, for instance [11], show that, besides the evident advantages, international exchange is surrounded by some concomitant problems. As a result, several groups of students and staff cannot enjoy mobility [12].

The goal of this research is to enhance intercultural competences of engineering students by overcoming the main intercultural barriers recognised during the case study devoted to the international exchange. In order for approaching the goal, some educational modules are revised, the reasons of inactivity of certain groups of students are found out, and useful steps are offered to improve mobility outcomes. A related goal of this study is to help students guide their own education and to suggest useful references for university staff in improving their current curricula.

In the following sections, the methodology of the research is described along with the case study explanation and the results are presented followed by the discussion and concluding observations.

2 Methodology

In 2019, above 5000 young men and women (11% of the full student contingent) came to Estonia for study from 126 countries, including 55% from EU and 30% from Asia. Current research was piloted in 2019–2020 academic year with bachelor and master short-term and long-term participants. Inter-EU and non-EU learners comprised the studied cohort. Alongside them, local (domestic) students were involved in this research as well. As a whole, four groups of students were addressed:

- two groups of non-EU students from Georgia, Ukraine, Turkey, Pakistan, Japan, China, Korea, and Tanzania alongside with EU students from Germany, Spain, Portugal, and Italy studied ATV0080 Supply Converters and Control of Machines;
- two groups of local students studied EEV5040 Industrial Automation and Drives;

In total, about 100 students enrolled two disciplines, syllabuses of which included lectures, exercises, and laboratory classes. At that, numerous nationalities with different cultures were represented in the target contingent using English as an instruction language not native for all of them. Thus, the diverse learning environment enabled everybody to gain multicultural experience at equal education quality. Both courses were organized in the form of topics, further divided into main parts, equivalent to lectures. Educational resources were represented by tutorials, e-textbooks, manuals, and slides with animations and computer models available on YouTube and TalTech sites, uploaded to the Moodle learning management platform, and can be read online and/or downloaded. In the course continuation, participants had deadlines for completing assignments, while there was no time limit to view the results and seek help from the teacher. Some features of this approach were introduced in [13].

Assessment rules were formulated before the course began. Most assignments are based on data stored in the repository and include a wide range of subject concepts designed to test the competence and cognitive level of the test-takers. To estimate the performance of the participants and its dynamics, a set of quantitative indicators was determined based on a number of a-priori established criteria [14] including the number of questions in the repository, author bias, and input consistency. To reduce cheating, test-takers randomly select questions based on these attributes.

To organize assignments in line with teaching content, the assessment procedure consists of the following parts:

- optional formative assessment of each topic in order to connect the theoretical material with real life situations;

- optional formative assessment during and after lectures to encourage students to actively acquire knowledge;
- mandatory formative assessment in the laboratory with optional parts to enable students to solve practical problems using experimental tools;
- mandatory formative assessment in the framework of computer exercises with optional additions to motivate students to work with professional toolboxes;
- mandatory summative assessment (exam) at the end of the semester to assess the pre-determined learning outcomes.

In accordance with the specifics of engineering [15], the methods of assessment at the undergraduate level include single or multiple choices quizzes, matching tasks, dichotomy tasks, and the ordering of statements suitable for oral accounting or logical inference. In contrast to the magistracy, these methods quite well reflect the real state of success of students. Filling problems with ambiguity questions and issues that need to be evaluated manually, as well as creative tasks are used at the master level.

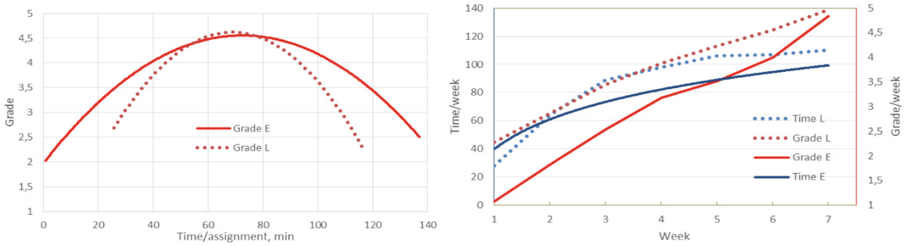
Voluntary participation in regularly conducted formative assessments (personalized quizzes, tasks, and questions distributed to students via Moodle) provided students with bonuses to the final exam. Each correct answer increased the student's bonus, while an incorrect one decreased it to the same extent. The assignment was open for a fixed time, usually from lecture to lecture. During this period, the number of attempts to answer was not limited, and only the last one has been counted. Correct answers were published immediately after the assignment is closed and stored on the site until the exam. The bonus collected during the semester was used by the teacher as a preliminary examination grade of the student. Final exams were organized in the same way based on the problems from the same repository. In total, ten to fifteen formative assessments for optional use and a package of mandatory final exams covering all levels of the studied areas have been applied for each discipline.

3 Results and Discussion

Figures 1 and 2 display the trends of assessment results recognised after the session end and averaged over the semester continuation.

Figure 1(a) demonstrates that the best marks are achieved by those who spend around one hour on a separate assignment. Part of students dedicates too little time whereas others waste their time in vain. It is remarkable, that to get the same grade, international exchange learners spend more time than their local classmates spend. It means that an averaged local learner is capable to find faster the sources of information (textbooks, lecture notes, Internet resources, etc.) to answer quiz questions and solve assignment tasks. According to Fig. 1(b), at the beginning of study an averaged international exchange student absorbs the discipline much slower than its averaged local classmate does. He/she devotes less time and gets smaller grades. Later, an international exchange student increases the rate of knowledge acquisition and succeeds in learning.

At the same time, it was found that the international exchange learners themselves vary greatly both in their utilisation of time and in assessment. Therefore, an additional



a. b.

Fig. 1. Ratios of assignment grades and times spent on a separate assignment (a); Grades and times taken for formative assessment (b) by international exchange students (E) and locals (L).

investigation was carried out within the international exchange cohort. To this aim, all learners were divided between EU and non-EU groups. As follows from Fig. 2, both the best formative assessment scores and the best examination grades are recorded in the EU group whereas the lowest scores belong to the non-EU students. The picture is similar across many other disciplines in the Engineering Faculty.

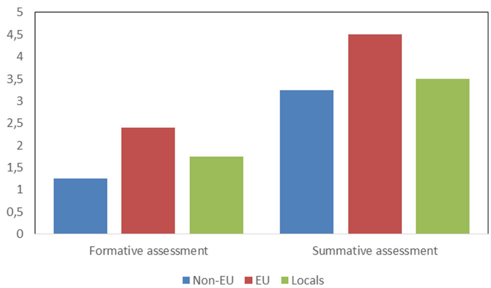


Fig. 2. Average assessment results recognised after the session end.

To identify the reasons of failing and/or success, the international exchange students were surveyed and their responses were compared with the similar answers of the local students who were previously involved in international exchange. Totally, the feedback from 90 learners was studied. The following statements with agree/disagree choices and comment fields have accomplished the poll:

- I acquired the knowledge and skills described in the learning outcomes;
- The workload of the course corresponded to the credit points;
- I made my best to contribute to studying (participation in lectures, seminars, independent work, homework, etc.);
- The organisation and structure of the course was logical and easy to follow;
- The study materials were relevant (up to date, comprehensible and related to the subject);

- E-support to the course (electronic learning environment, digital materials, etc.) helped me acquire the subject;
- Evaluation was carried out in line with the evaluation criteria;
- The lecturer was able to pass on his/her knowledge to students;
- The teaching methods used, the exercises and other activities carried out by the lecturer provided me guidance and motivation to learn;
- The lecturer provided relevant and timely feedback to my studies;
- I was satisfied with the lecturer's communication skills in English.

Analysis of these responses, comments to the above statements, compared to the examination grades revealed that classes encompass students with a variety of learning styles and methods of learning. Due to differences in prior knowledge, motivation, and cognitive capabilities, learning success is very specific for each individual learner and for various groups of learners. In this diversity, the focus in this research is to the most homogeneous subgroups with a similar learning behaviour and rather common learning style [16] aiming to understand the reasons of their failing or success and to develop adequate learning settings for different cultures.

It was found that much more non-EU students than their EU and local classmates failed in overcoming such barriers as deficiency of social interaction and lack of personalization at large amount of studied topics. As other sources of weakness, it were recognised insufficient information about assessment, impossibility to share time correctly between different learning activities, spontaneous learning styles, and wrong choice of priorities. Weak students called inappropriate (in their view) course methodology, substantial volume of material reviewed, complexity of tasks, and incomprehensibility of the assessment questions. Apart from these, several non-EU respondents mentioned such practical issues as housing, financial and visa problems. Based on academicians' feedback, non-EU students demonstrated higher propensity to cheating and other academic dishonesty.

Among failing travellers, this research has shown those who arrived very late, when other learners had already begun their study. Along with them, there exist a number of weak and "slow" students, who find it difficult to understand engineering subjects and to solve educational problems in the host institution [11]. Degree of involvement of these students in study processes and their scoring are much less, than the strong students have. On average, they demonstrate less concern in optional formative assessment and, as a result, lower final grades. The notable challenge was a language barrier that some students faced in communication. Often, international participants took additional time to run the study at the host university that delayed their learning.

At the same time, non-EU students found many benefits from contacts with EU and local students. These participants reap the most advantages from international exchange comparing to EU and local learners. Peer-to-peer contacts during studies appeared as an effective way to develop inter-personal communication and intercultural competence and significantly promoted their employability. Particularly, most of respondents mentioned that working with classmates from other cultures helped them gain additional knowledge on a subject. A raise of student motivation and an improved mastery in English were also mentioned. Those who faced difficulties in English were thankful to the more experienced partners for help, adjusting their communication abilities, and promotion in material understanding.

Notably, integration is implemented easier for EU students than for non-EU ones. The EU learners generally have even better grades then the local students. Most of EU participants are well prepared both in English and in their future speciality. Nevertheless, EU students note other reasons of dissatisfaction with international exchange. Among them, poor connected calendars of universities, unavailability of courses in the visit time, inconsistency of the course titles, overlapping of the disciplines, outdated information on the web, non-fluent English deficiencies from both the students and the staff sides, etc. By surmounting most of these obstacles, international exchange outcomes might be increased.

4 Conclusions

This research revealed two categories of students. Those travellers achieve much benefit from international exchange, who was carefully prepared both in English and in their future speciality. Less successful are the participants with inappropriate educational and cultural level. Organisation of their mobility is to be changed on the administrative level. To gain success in academic mobility, it is proposed to make lessons more individual and targeted to largely homogeneous subgroups of learners that differed by their cultural and educational background.

It seems reasonable to change the curricula in such a way that the course syllabi were adapted to real students' background. It concerns the pre-requisites for enrolment, the lecture and the practice hours, recommended literature, etc.

A more thorough preparation for the visit might be recommended as another side of international exchange improvement. Timetable and curricula agreement as well as the choice of studied disciplines have to be executed long before the travel.

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Transition from Classroom Teaching to E-learning in a Blink of an Eye

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Abstract. The main purpose of this paper is to give an overview and the lessons learnt about the abrupt transition from traditional classroom teaching to distance learning based on the experience of Tallinn University of Technology (TalTech). The rapid outburst of the COVID-19 virus led to a situation that the government had to shut down all the schools and universities and all the teaching activities had to be carried out without physical contact. The universities had one weekend to conduct the transition. The influence of the rapid change in teaching practice was analysed using the feedback of the study program directors, students and academic staff. The main enablers and disablers with the main constraints are presented. Analysis showed that the transition is impeded both by the lack of technological solutions (i.e. remote usage of laboratories) and by human resources (i.e. skills and willingness to conduct the transition by the academic staff). The unique and hopefully non-recurrent situation enables to analyse both the institutional, technological and personal readiness to adapt with the rapid changes in teaching practice. The outcomes of the experience will be used to improve the readiness and competences at all levels at TalTech.

Keywords: Classroom teaching · E-learning · Transition

1 Introduction

Over the years a number of e-learning environments and approaches were used in Tallinn University of Technology (TalTech) which led to the situation where students had to adopt with and have multiple user accounts to use the environments. The level of the e-learning support was volatile and the definition of the support was used very creatively. The presents of e-learning support was optional and not regulated at the university level.

Therefore it was centrally decided that from spring 2018 all compulsory courses in TalTech had to have an e-learning support. For that, the university set up its own e-learning environment based on Moodle and defined minimum requirements for the e-courses. Although the initiative was successful, until this spring a minority of the courses were taught only in e-learning environment (which was actually not set as a goal). In most of the cases, the e-learning support was just assisting the classroom teaching.

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The rapid outburst of the COVID-19 virus in Estonia in March 2020 [1] led to a rapid transition from classroom teaching to e-learning. This meant that all the teaching activities had to be carried out without physical contact. The universities had one weekend to conduct the transition.

It is evident that neither the institution nor the students and academic staff were ready for such a giant leap in changing the teaching practice in just a few days. Nevertheless the university reacted very quickly and launched precise and clear instructions for the academic staff how to carry on with the teaching activities. Two factors – availability of the support and clear guidance form the Educational Technology Centre and presents of the e-learning support for all compulsory courses – were enabling the transition for the academic staff. For example before the transition in the School of Engineering 94% of all compulsory courses had the required e-learning support. At the university level, the percentage was 88.7 being lowest at the School of Information Technology (69%). The three major disablers for the transition were short time frame, motivation, preparation and willingness of the academic staff and limited or no remote access to the infrastructure (i.e. lab facilities). The enablers and disablers of the transition are listed in Table 1.

Table 1. Enablers and disablers that affected the transition to e-learning

Enablers	Disablers
Most of mandatory courses had e-support	Short time frame for the transition Preparation of the students and staff
Available guidance from Educational Technology Centre	Limited or no remote access to the laboratory infrastructure
Some lecture rooms were equipped with technology needed for online lectures	Large number of courses that include practices and lab measurements
Most of the staff and students were familiar with the tools for online meetings/lectures	Large number of different tools that were used for online meetings/lectures

This paper analyses the possible constraints of such abrupt change in teaching practice to the overall teaching quality and outcome. Potential impact of the transition with the lessons learnt is discussed.

2 Initial Phases of the Transition

The influence of the rapid change in teaching practice was analyzed using the feedback of the study program directors, students and lecturers. The timeline of the crisis is presented in Fig. 1 to show the information flow throughout the event.

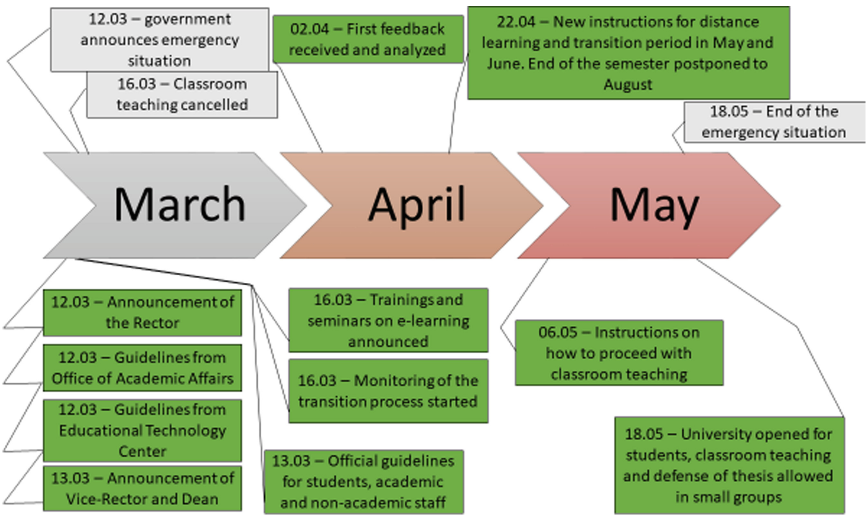

Fig. 1. Timeline of the transition. Actions marked in gray were initiated at the government level, actions marked in green were initiated at the university level

The School of Engineering started to collect the feedback from the study program directors from the first day to support the transition. An online form was set up to collect the information. Online meetings were held to gain more specific details about the shortcomings in the study process. Different measures were analyzed on how to support the transition process and the impact of the rapid transition was studied throughout the especial event. Students feedback was collected indirectly (through the feedback of the study program directors and dean's office personnel) and directly through interviews.

The collected data was and will be used for two purposes:

1) Overall management of the transition during the especial event. Feedback from all parties was be used to support the decision making process and to propose different measures to mitigate the transition. This includes for example sharing the guidance materials and contacts of the Educational Technology Centre, contacting the academic staff whose contribution to the transition was weak, activating students to take part in the distance learning, analyzing the situation and potential threats.
2) Summarizing the feedback for future crisis and analyzing the success of the transition at the institution, study program and individual course level. This will enable to identify the short comes and potential to further develop the e-learning environments and to diversify the teaching practices based on the needs of single courses and the frame of reference.

The generalized responses from the study program directors and students are brought forth in Table 2. Around 80% of the study program directors gave their feedback to the transition process during the first two weeks.

Table 2. Collected responses from the study program directors and students during first two weeks of the event

Feedback from study program directors	Feedback from students
Most of the courses continued in online format using different online platforms	Some courses were delayed, no information how the learning process will be carried on
Problems with guest lecturers as they do not have user accounts for some of the online platforms	Students got a lot of individual assignments, the teaching part was forgotten
Problems with special software, not enough licenses to be shared with students	Information gained from the lecturers was vague
Problems with students laptops/PC-s, hardware is not capable to run simulation programs	Problems with lab work and practices
Labs postponed to May-June	Students preferred that lectures carried on in online according to the study plan before the crisis
Problems with setting up virtual laboratories because of cyber security issues	No contact with some of the lecturers

Based on the feedback the critical courses were identified and the responsible lecturers were contacted at the university, school/institute and study program level. In most cases, it was possible to carry on with online lectures. Only a few courses postponed the activities for March and April.

The more-or-less smooth transition from classroom teaching to e-learning was greatly supported by the rapid reaction at the university level. University had three days (including a weekend) to prepare guidelines for the staff and students about the teaching process during the emergency situation. Over the weekend clear guidelines were prepared. This included instructions for students, staff, about events and work-related gatherings, rules at the university's premises and services and general recommendation. At the same day a guideline was sent to all lecturers with recommendations how to carry on with the teaching and on what platforms. A Facebook page for events, news, instructions and recommendations was set up for rapid information sharing. Sample classroom was prepared in MS Teams with guidelines how to use it for teaching purposes. Webinars and online courses about online teaching were announces for the coming weeks.

In the end of April it was evident that the peak of the COVID-19 crisis was exceeded. Therefore new guidelines for staff and students were announced on 22nd of April. Based on the current knowledge it was assumed that in the near future, some sort of face-to-face teaching would resume by the decision of the Government of the Estonia also in higher education institutions. Therefore it was proposed that studies at TalTech would be organized as follows:

- Majority of the courses would be completed according to the academic calendar.
- Majority of the exams and assessments would be completed according to the academic calendar.
- In exceptional cases and in compliance with the rules of the emergency situation, face-to-face teaching could be carried out also during the examination period.
- It should be ensured, however, that students are able to complete their courses also by distance learning methods (since some students have left for their home countries abroad, some are in quarantine etc.).
- At the request of the study program director and by dean's order, the deadline for completing a course can be shifted, if necessary, to the end of August. The study load of students at the end of academic year will be calculated after that.
- The deadline for the defense of graduation theses is according to the academic calendar. In exceptional cases, the deadline for the defense of graduation theses may be extended until the end of August in accordance with the procedure established by the dean of the school.
- In exceptional cases, it is possible to defend a graduation thesis conditionally, i.e. a student is allowed to defend his/her graduation thesis even if he/she has not completed all the courses included in his/her study program.
- The deadline for confirming the study place was extended until 30th of August, in order to give the bachelor's and professional higher education graduates the opportunity to continue their studies at the master's level at TalTech starting from the autumn.
- The festive graduation ceremonies were cancelled.

3 Actions During and After the Transition

In the beginning of May it became evident that the emergency situation will end in the coming weeks. The deadline of the emergency situation declared by the government matched with the end date of the spring semester. Therefore last two months of teaching was carried out in distance learning. At the same time data about the courses that needed extension were identified at the university level. Similarly the number of students that needed extension for their defense of graduation thesis were compiled.

At the School of Engineering 403 courses were taught in the spring semester. Out of the 403 only 25 courses were extended and the completion date was set to August. This is 6% of the courses which is very low taking into account the number of courses that include laboratory and/or field practices. In addition 15 of the 25 courses were from one study program. In that case the postponement of the courses was agreed at the institutional level. Therefore the actual need for the postponement was even less.

Similar trend was seen with the defense of the graduation thesis. In total 556 students submitted an application to defend the thesis. Out of the 556 only 33 requested for postponement of the defense to August. This makes again $\sim$ 6% of all the applicants. Nearly half of the requests (16) were from the study program of architecture.

Two questionnaires were prepared at the university level to analyze the transition to distance learning in the perspective of students and academic staff. At the university level it was decided that students opinion will be gathered during the periodic feedback (twice a year after the semester). At the schools level the approach was somewhat different. In some schools, where the number of students was lower, it was decided to send out specific questionnaires about the transition process already in May when the emergency situation was not yet over. The School of Engineering decided to add some questions related with the transition process to the periodic feedback questionnaire. All the statements are assessed from 1 to 5, where 1 stands for "Completely disagree" and 5 stands for "Completely agree". All questions have possibility to add comments. The additional questions were as follows:

1. Information about the changes in the organization of the studies was available and timely
2. Distance learning was (generally) well organized and supported learning
3. The selected e-learning environments supported me in conducting my studies and my active participation as a learner in the learning process. Add to the comments your preferred e-learning environments
4. Staff in the dean's office was supportive and good-natured when solving the upraised problems
5. Lecturers reacted quickly and adequately when problems upraised

Questionnaire for the academic staff was sent out to all lecturers just before the emergency situation was over. The questionnaire was opened for one week and lecturers were asked to answer the questionnaire based on the courses they taught. This meant that there were multiple answers for one course (if there were more than one lecturer) and from one lecturer. All-in-all 171 unique answers were gathered about 172 courses. The following aspects were asked from the academic staff:

1. Your name
2. Code of the course
3. Please choose all methods you used during distance learning
   a. Online lecture according to the timetable
   b. Online practice/seminar according to the timetable
   c. Online group work
   d. Online consultation
   e. Recorded lecture (uploaded to Youtube, Moodle etc.)
   f. Practice session solution sheets (without additional verbal explanations)
   g. Lecture presentation for individual studying
   h. Individual reading instead of a lecture (e.g. a chapter from a book)
   i. Other

4. Please choose all tools and/or learning environments you used during distance learning
   a. MS Teams
   b. Zoom
   c. BigBlueButton
   d. Google Classroom
   e. Google Hangouts Meet
   f. Discord
   g. Moodle
   h. Facebook
   i. Skype
   j. Other
5. Based on your experience, please rate how has distance learning affected the following student related aspects:
   a. Participation in lectures/studies
   b. Acquisition of learning outcomes (number of students achieving positive results)
6. Information about the changes in the organization of studies was available and timely
7. The selected e-learning environments supported me in conducting my studies and my students active participation as a learner in the learning process
8. What have been the positive aspects of conducting studies during this distance learning period? Please explain.
9. What have been the negative aspects of conducting studies during this distance learning period? Please explain.

Questions 6 and 7 were added to the questionnaire only for the academic staff in the School of Engineering. The idea was to have some of the questions in both of the questionnaires (students and academic staff) to compare the results on information sharing and e-learning environments.

The results for some of the questions are presented in the next section.

4 Results and Discussion

Taking into account the feedback gathered during and after the emergency situation it can be concluded that the rapid transition from classroom teaching to distance e-learning was successful. Tallinn University of Technology was quite well prepared both on the e-learning support and technological readiness but the main uncertainty was on the readiness and motivation of the staff and students to adopt with the transition. Luckily the staff was motivated and reacted on time. This can be seen from Fig. 2 where the change of percentages of the mandatory courses equipped with proper e-support are shown.

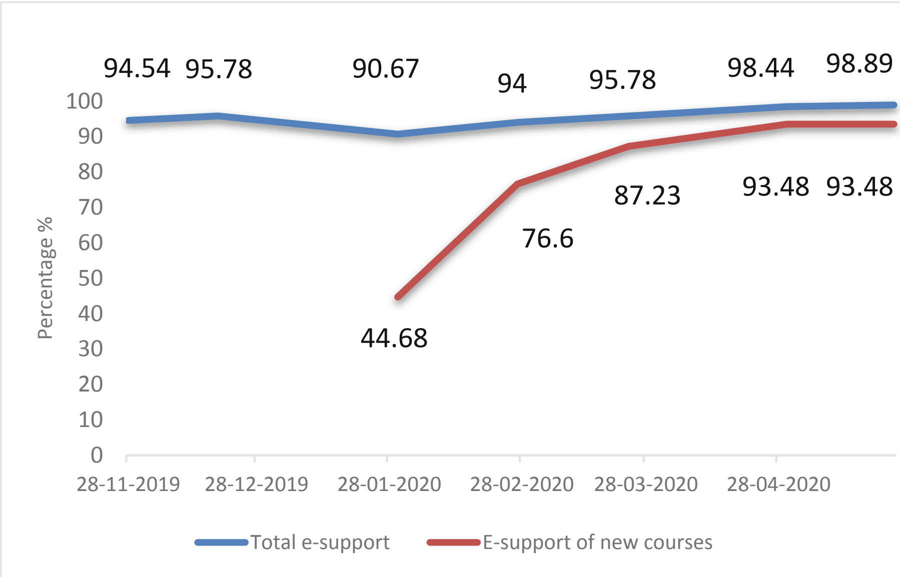

Fig. 2. Changes in the percentage of mandatory courses that had e-support during the emergency situation.

Blue line shows the number of total courses that had e-support at the School of Engineering and red line shows the percentage of the new courses that had e-support and were taught for the first time during the spring semester. At the beginning of the semester (beginning of February), less than half of the new courses had proper e-support. This number increased quite rapidly during the first months and reached around 85% at the beginning of the COVID-19 crises. At the end of the semester only 6 courses (~1%) did not have an e-support with all the necessary elements according to the university's standard. Lecturers of most of the courses were specialists outside of the university and did not have enough time and/or knowledge to set up the required e-support. In that case members of the academic staff (either program directors or fellow lecturers) were asked to assist them during the process. Extra work of the academic staff members was reimbursed.

First feedback about the transition process at the university level was gathered from the lecturers. Figure 3 shows the lecturer's satisfaction about the information exchange and relevance during the crisis and their opinion on the available e-learning environments. It can be concluded that the information exchange at the university was very good. Majority of the lecturers (~91%) rated this with 4 or 5. The average satisfaction was as high as 4.47. The availability of proper e-learning environments was rated high as well (~86% rated with 4 or 5) but the average satisfaction was a little bit lower at 4.23. This is understandable as the rating is more subjective. Real fact based conclusions can be drawn after the examinations.

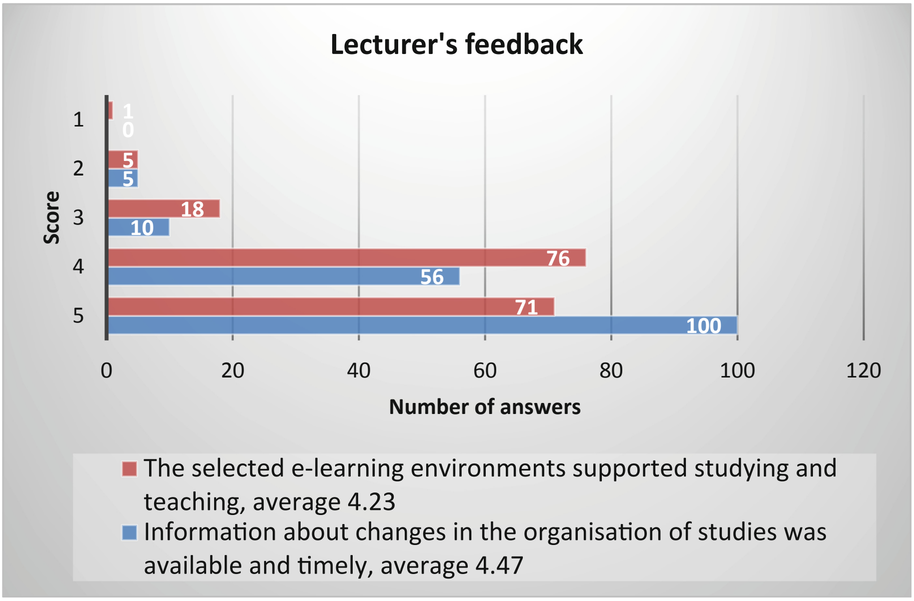

Fig. 3. Lecturer's feedback on information exchange and e-learning environments

Figure 4 gives a very good overview how the students reacted to the transition. It is good to see that in majority of the classes the students' participation did not change or even improved (75%). Still it has to be reckoned that in 25% of the cases the students' participation decreased. This is not only affected by the crisis. Previous studies on class attendance have shown that the number of attendees decrease during the semester [e.g. 2, 3]. A study carried out in an elite Economics school in Portugal [2] showed that the class attendance decreased from the start of the semester from 84–95% to 49–66%. The percentage of average attendance was more-or-less linearly decreasing throughout the semester. Similar trends were reported in a study performed in Technical University of Denmark taking into account information received from nearly 1 000 undergraduate students [3]. It was shown that the attendance differed based on the students performance but decreased in all performer groups. Therefore it can be concluded that the transition process was successful as majority of the lecturers (75%) did not notice a remarkable decrease in attendance and in some cases the attendance even improved.

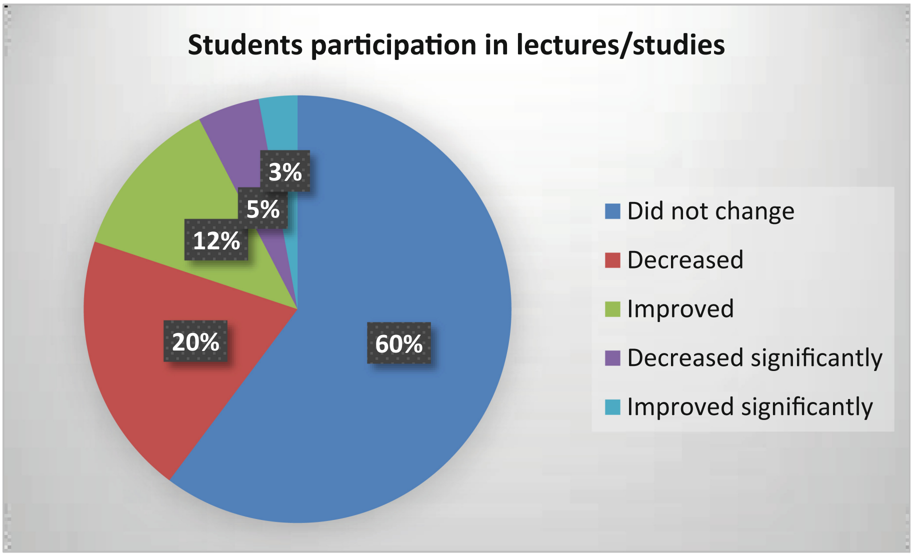

Fig. 4. Students participation in lectures according to the feedback of lecturers

Figure 5 presents a subjective assessment of the lecturers on the students' performance and how they obtained the learning outcomes. Nearly 3/4 assumed that the rapid transition from classroom teaching to e-learning did not affect the performance. 14% reported that it had a negative impact and 13% reported a positive impact. This data will be used to compare the actual students' performance after the examination to see the real effects of the transition.

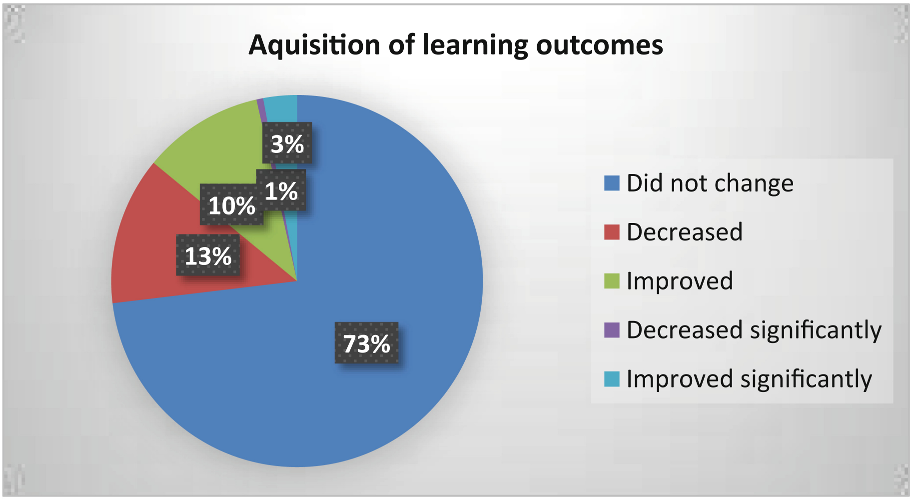

Fig. 5. Acquisition of learning outcomes according to the feedback of lecturers

5 Conclusions

The process of a rapid transition from classroom teaching to e-learning based on the experience of Tallinn University of Technology was analyzed. It was shown that the successful transition was enabled by the fact that most of the mandatory courses had e-support before the crisis. In addition clear guidelines were present and rapidly prepared by the Educational Technology Center to support the lecturers. It was evident that not all the laboratory measurements and practices could be transferred to online environment in just a few days (or even months). Another constraint was the readiness of lecturers and students to switch to a new teaching method in a blink of an eye.

University started to gather data (both centralized and decentralized) from the first day of the transition. This enabled to detect the courses where the transition to e-learning was postponed and the lecturers who struggled with the set-up of e-learning environments. This resulted in a low number of courses ($\sim 6\%$) where the teaching activities were postponed to June-August. Similarly only $\sim 6\%$ of the students postponed their defense of the thesis indicating that the collaboration with the supervisors carried on successfully in online environments.

Feedback gathered from the lecturers indicated that the rapid transition did not have a significant effect on the class attendance. Moreover in most of the cases the class attendance remained the same or even increased compared with the situation before the crisis. The students' performance can be assessed after the examination period. The lecturers' subjective opinion indicates that the performance is expected to be fairly good.

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Adaptive Starting Points in Video Learning Environments for New Learners Based on Video and Topic Tree Relations

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Abstract. Teaching and learning complex fields of knowledge, including engineering, is rarely easy, particularly because of rapid changes and high interdependences among different topics. In addition, learners are increasingly heterogeneous in terms of different experiences and levels of knowledge. Not dealing with increasingly heterogeneous learners appropriately may result in high dropout rates and poor training quality. A possible way out is addressing learners more individually. Hopefully, digital learning offers, such as video platforms, will help to convey knowledge better and more individually through a broader learning offer. But learners with different levels of knowledge need different starting points into a course based on their level of knowledge. Thus, a crucial problem is finding the most appropriate starting point for learners in such environments. This paper presents a novel approach to identify individual starting points in online video courses for learners with different levels of knowledge. The underlying algorithm identifies topics that are most useful for the concrete learner at the beginning of the course in order to introduce a new field of knowledge appropriately.

Keywords: Adaptive learning · Video learning · Heterogeneous learners

1 Introduction and Motivation

Educational institutions and learning platforms need to cope with increasingly heterogeneous learners [1]. Heterogeneity is not new, but the range of heterogeneity among learners gets larger. Especially in a university context, this is, e.g., due to the fact that some beginners are much younger or much older than average, and there are more and more lateral entrants after training [2]. The range of heterogeneity becomes even wider in postgraduate programs. Beginners may arrive directly from a Bachelor's program or, conversely, after many years of work and practical experience. The difference in levels of knowledge is therefore even more blatant. Accommodating heterogeneous learners is not easy, especially in advanced and complex knowledge topics like engineering. Learners bring different experience and levels of knowledge to educational institutions and learning platforms. The success rate of a course (in direct as well as in online teaching) strongly depends on how the target group is treated. The success rate includes whether learners complete the course "successfully" (completion of the course and acquirement of knowledge). Once different levels of knowledge in a

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course are not accommodated properly, high dropout rates and poor outcomes are likely. Consequently, learners need to be addressed more individually, which is more difficult in classic face-to-face teaching than in digital learning environments. This paper tackles the "heterogeneity" problem by using a video learning environment due to its high popularity and suitability for blended learning [3]. Diverse learners in video learning environments may be addressed more individually through recommendations of appropriate video learning paths. But then, a crucial problem is identifying the proper startup since otherwise learners might be overwhelmed, bored, or confronted with issues that do not suit their current needs. That is, where should a learner start learning? Which topic should learner look at first, depending on their current level of knowledge of the entire topic complex? The more complex a course/topic field is, the more difficult it is for learners to make the initial decision.

Usually, instructors set out a structured order of learning items (a recommended learning path) which is identical for all learners. Yet, a one-size-fits-all solution is not useful for learners of different knowledge levels and experience. If increasingly heterogeneous learners are not dealt with, there is a risk of high dropout rates and poor quality in training. Therefore, it is desirable to offer each learner a suitable introduction to the topic, depending on the specific level of knowledge.

The startup problem is also a technical issue. Classic recommender systems only work when a sufficient volume of data is available, otherwise they suffer from the popular "cold-start problem" [4]. Unfortunately, at the beginning of a course, learners are not known and therefore no data are available to generate tailor-made recommendations. Classic recommender systems do not work due to the lack of data and, consequently, the cold-start-problem. Thus, a new approach is needed.

This paper presents an approach to identify individual starting points (so-called entry points) in any online video course, given learners with different levels of knowledge on a topic. To do so, we devised an algorithm which computes topics which are most useful for the concrete learner at the beginning of the course from thematic questionnaires that are correlated with defined topic trees. A topic tree in this paper can be viewed as a lightweight ontology [5] of the specific course topic. Each course deals with a main topic, e.g. programming with Java, which branches out into several subtopics (building blocks). The tree connects questions of the questionnaire, course topic, and concrete video content by linking questionnaire responses to specific topics of the course and video content to identify individual lack of knowledge in specific subtopics. A selection of learning videos that can be used for the beginning is derived from problematic topic areas. The approach's performance depends on the complexity of the chosen topic. While it does not pay for topics with few videos, our recommendations make sense for complex topics with many videos, as it is much harder to decide which video to start with. For this reason, topics such as engineering are particularly suitable due to their complex interrelationships. The paper demonstrates the approach using a programming course in a university context.

This article's main contribution is a novel algorithm that is able to determine individual recommendations, depending on each learner's individual knowledge level, as a starting point in a video learning course. Each learner's current state of knowledge is recorded by self-assessment via a questionnaire. Individual starting recommendations offer the learner a tailor-made introduction to the chosen subject area.

2 Research Question

This research tries to simplify the entry of heterogeneous learners with different levels of knowledge and experiences into a specific topic by computing start recommendations in video learning platforms. The underlying research question of this paper is as follows:

How can the entrance in video learning courses of complex fields of knowledge be tailored specifically to each learner's level of knowledge?

As a proof of concept, the developed approach is applied in a programming course in higher education.

3 Related Work

Dealing with heterogeneous learners is always challenging for instructors. Without technical aids, suitable procedures can only be recommended by observing and asking learners individually. On the technical side, recommending useful course items is, in principle, a task for recommender systems, which are popular in online marketplaces and entertainment systems. In learning environments, recommender systems only became popular in recent years [6, 7]. Generally, most recommender solutions are based on preferences or similarities and need large volumes of data for appropriate recommendations. Collaborative or content-based filtering are standard approaches to predict useful items [4]. The former approach works with the data of other users and their behavior in an environment. That is, users are implicitly monitored or directly queried to obtain data [8]. The latter approach compares pieces of content in such environments. In a learning context, these techniques are helpful in big online environments like MOOCs due to the large amount of available user data [4, 9]. Yet, two problems need to be solved: For one thing, learning environments with few learners do not generate many data, i.e. recommendations need to be derived from a much smaller database. Secondly, all systems are exposed to the so-called "cold start problem", which means that a recommendation is only possible given a reasonable amount of data [4, 9]. Recommendations where to start can only be given based on already available data, but the actual knowledge levels of the new learners are not taken into account. For this reason, the classical approach to tackle the startup problem is only partially effective. Existing approaches try to solve the cold start problem by, e.g., importing demographic data from other systems (e.g. social networks) [9] or using meta data to predict user profiles, trends, and patterns. Patterns are based on content similarities, users, and resources [8]. Yet, these approaches do not provide any information about the concrete knowledge of individual learners in a specific knowledge area. As an alternative, ontology-based recommender systems might come into play. The underlying idea of these systems is to describe mappings between the concrete domain area and users. The aim is to create user profiles including implicit and explicit information. In our context, obtaining implicit information would rely on many data that we cannot access. Obtaining explicit data is not easy either. Often questionnaires are used to obtain this information, although users are rarely keen to complete them [10]. Our approach uses a lightweight ontology – a topic tree – and learners' self-assessments to create more precise and focused initial recommendations.

4 Starting Point Problems in Learning Environments

Each learning project begins with an introduction to the respective subject area. Traditionally, each learner starts at the same point (no individual introduction). Especially in classroom teaching, adaptive entries can only be realized at the expense of increased supervision effort. The entry is as important as the supervision during the learning process. There is always the danger of a loss of motivation due to poor supervision and consequently the termination of the learning project [11]. The risk of learner jump-off is particularly high at the entry point, where learners' interest can be aroused. If the introduction is too simple, learners can quickly get bored; otherwise, he can get frustrated quickly. Both options can lead to dropout or decreasing motivation to dive into the new field of knowledge. Thus, it is all the more important to ensure a smooth start to learning. This is hardly feasible in face-to-face education and quite impossible in large learner groups. Yet, digital learning environments allow determining more adaptive introduction points. Thus, these systems may avoid the problems mentioned above, once ways of tackling the typical cold-start problem have been found, in spite of technical challenges due to a lack of information on individual learners early on (see Sect. 3. Related Work).

5 Recommending Adaptive Starting Points

This paper presents an approach to make it easier for learners with different level of knowledge and experience in a specific superordinate topic to get started with a video course. To that end, we offer learners appropriate entry points based on their levels of knowledge, such that they can get into the respective subject faster and more sensibly. This is accomplished by computing recommendations for individual starting points in video learning platforms.

Initially, no database of previous learners and no specific information about new learners is available. Thus, traditional recommender systems may not be used due to the cold-start problem, i.e. no prediction without big existing datasets [6].

Information on new learners is collected by asking them in questionnaires about their current familiarity with the topics in the associated course. These questionnaires must be linked with the actual content of the learning platform. For this reason, the subject matter is transformed into a so-called topic tree, a kind of a lightweight ontology.

This approach has both advantages and disadvantages. Some learners may not be able to assess themselves, but still an initial set of data will result. Another problem is that not all learners are willing to complete such questionnaires.

5.1 Topic Tree – A Lightweight Ontology

As a first step, the complexity of the subject matter in question must be understood for determining the current knowledge level of a learner as well as possible. To determine learners' knowledge levels, their lacks of knowledge need to be identified. To this end, the top-level topic is broken down iteratively into subtopics, ending with elementary subtopics at the lowest level. Consequently, subtopics depend on each other. That is, Topic A, e.g., is the superordinate topic of Topic B. Topic B is usually a subtopic of Topic A (see Fig. 1). These interdependent units give rise to a simple topic tree which is a lightweight ontology. Each unit/subtopic is a node in that tree (see Fig. 2). The tree is always read from top to bottom. The individual levels thus represent the sequence of processing (from top to bottom). Nodes in higher levels can also be a prerequisite for nodes in lower levels. This means that, e.g., Topic B can only be understood if Topic A is already understood to some degree.

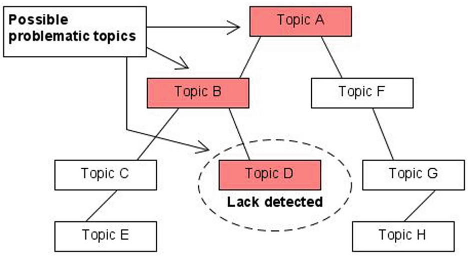

Fig. 1. Example of lack detection

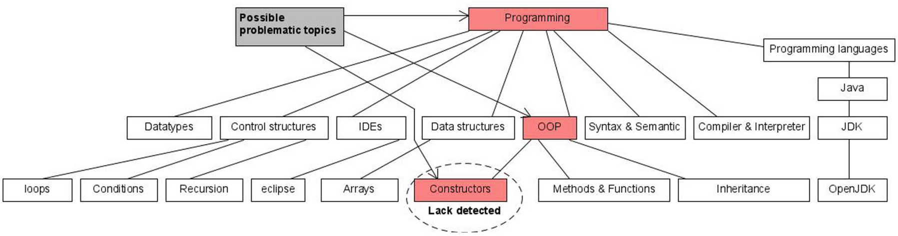

Fig. 2. Topic tree of the course "Programming with Java" including an example of problem detection

Ontologies originated in philosophy [12]. Computational ontologies are used to structure a system including entities, relations, and rules [10, 13] and usually represent a knowledge model with a semantic description. There are lightweight and heavy-weight ontologies. A topic tree represents the former since it represents more general relationships to the individual entities and less formal descriptions than heavyweight ontologies. Heavyweight ontologies extend lightweight ontologies with constraints and axioms [5]. Each single node of a topic tree is associated with a subtopic of the whole subject matter. The more specific a subtopic is that is associated with a node, the easier it is to get an approximate level of knowledge by asking learners about their knowledge of a single subtopic. Consequently, the more precisely a single node captures a subtopic and the more specific the related question is, the higher is the chance to get a meaningful result for this node. It is important to find out where a gap occurs, but also how it is caused. The dependencies between the nodes indicate topics which may be responsible for the lack of knowledge. For the recommendation of starting points, the cause of the problem also plays a role. Once a lack of knowledge is detected in the third layer of our tree (see Fig. 2), the lack may have two different causes:

- Cause 1: The learner accomplishes the requirements (upper topic-nodes/superordinate topics) in the topic tree, but struggles with understanding the current topic.
- Cause 2: The learner is not able to understand the current topic because he did not fully accomplish the requirements for this topic. This means there is only a partial understanding of required topics, i.e. parent-topics in our case.

If the second cause occurs, a topic which was not fully understood and lies higher up in the tree should be recommended instead of the current one (see Fig. 1). The idea is to consolidate the knowledge of the higher topics (in higher layers) to fulfill the requirements for the topic with the bigger lack of knowledge.

It is also very useful to spot the topic with the biggest lack in the tree since the recommendation algorithm does not need to check lower nodes in the tree once a serious lack of knowledge surfaces. In the following, we briefly explain the use of the topic tree in an introductory course for “Programming with Java” and supplementary learning videos (see Fig. 2). Learning videos are available for most topics covered in the course’s presence lectures. The root of the tree is the overall and most general topic, which spans the whole course. If a learner has no knowledge of the subject matter at all, we can conclude that he is a total beginner. Consequently, we can advise her to start with the very basics of this course. Our main topic “programming” is very broad and not specific. Regardless of the concrete programming language, it is quite relevant whether a learner already has experience with a programming language at all. In this case, the learner might be a total beginner specifically with respect to Java, but he may already know some basics that are identical in several programming languages. The deeper layers deal with various subtopics of the course. A parent topic often generalizes several subtopics in our example. This tells us whether a learner is already familiar with, e.g., control structures. If the learner has no experience at all, there is no point in looking at specific control structures, e.g. loops, as these cannot be known. Once we know an approximate knowledge level for each node, we may recommend adequate entries into that course. Each node must be associated with an estimate of the individual learner’s level of knowledge with respect to the associated content. This works easiest with a calculated score between 1.00 (high level of knowledge) and 0.00 (no knowledge). In order to calculate individual scores, we first collect information on the respective learner via a questionnaire. Overall, each topic node must be linked with a collection of videos of varying difficulty that can be recommended to the learner in the event of a match.

5.2 Getting the Knowledge Level by User Questionnaires

We determine the current state of knowledge via a topic query. Each query must refer to a single node in the tree. The better the tree has been created, the easier it is to create concrete questions. To compute the estimated knowledge level from the answers relatively easily, we use a Likert scale. A score can easily be calculated by dividing the entered value of the user by the Likert scale's maximum value (e.g. Likert size = 4, answer is 2, the score is 0.5). Table 1 presents sample questions for the course "Programming with Java". We used a 4 point Likert scale in order to force learners to express a tendency whether they know a subject better or worse. Odd-sized scales save learners from a commitment, which has disadvantages in the calculation. The Likert scale questions facilitate computing recommendations as well. Certain questions can be defined as "Knockout" questions, i.e. the questionnaire is automatically canceled if the score of such a question is 0. Learners cannot have knowledge on a topic if they lack knowledge of the topic linked to a knockout question. Still, asking learners any questions could be bug and feature at the same time as well. Actually, they cannot know the underlying topics. If, however, they can answer topics based on it with a score greater than 0, then this can have three reasons: Either learners do not understand the question, or lie. Or we have not correctly defined our prerequisites and dependencies in the tree. A faulty or bad tree structure can be spotted when several learners in deeper nodes indicate a relatively high level of knowledge compared to the actual prerequisites in the higher nodes. Our approach uses a hybrid solution. Thus, we can avoid meaningless questions as well as test the tree's fidelity and robustness in a certain way. In our case, asking learner about programming experience is a knockout question, because without any experience learner are total beginners. In deeper nodes, we avoid the knockout questions to get the desired information mentioned above. We mentioned above that questionnaires are very unpopular and rarely filled out. Since start recommendations at the beginning of a course need to be determined, we force learners to participate in this introductory questionnaire at the beginning of the course; otherwise they will not receive course admission.

Table 1. Sample questions for "Programming with Java"

Question item	Topic
Do you have programming experience?	Programming
Do you have experience with Java?	Java
Do you know the difference between syntax and semantic?	Syntax & Semantics
Do you know the difference between compiler & interpreter?	Compiler & Interpreter
Do you know what a for loop is and can you use it?	for-loop

5.3 Computing Starting Point Recommendations

After filling in the questionnaire, individual starting points must be computed by extracting all topics from the current questionnaire. We transform all relevant topic nodes (which are connected with our current questionnaire) to a new adapted topic tree.

Then, we have to spot "problematic" topics, i.e. all topics with which learners have problems. These are the basis for later recommendations. To grasp each possible topic, a depth-first search of the tree has to be done. We explore each branch in the tree until the last node. The last node is an elementary topic and cannot be broken down further. Before we compute recommendations, we define a threshold value (between 0 and 1) for each level of the tree. The threshold determines how deep we search a path. If a topic score falls below the threshold during the search, the respective topic is saved in the list of problematic topics and the search in the current path is aborted. In our example course, we used thresholds as follows (see Fig. 3): First layer: 0.25, second layer: 0.50 and from the third layer onwards: 0.75. We assume that the level of difficulty of the topics increases with their depth in the topic tree. The threshold makes a recommendation for simpler topics more likely if the level of knowledge is too low to consolidate the knowledge there.

Problematic topics are ranked according to the layer and the actual score. Higher levels are more relevant as they are prerequisites for lower levels. Lacks in higher levels must be fixed first. Finally, all topics are associated with a list of videos that cover these topics. After the ranking, we recommend a maximum of three thematic videos in order not to overwhelm the learner with the selection. Recommendations are sorted by difficulty level and based on the course sequence given by the instructor. We assume that each video course (analogous to classroom teaching in the case of blended learning) has a predefined course structure from the instructor. Usually recommendations can be provided at any time in such a learning environment, but in our case, we only want to provide start recommendations until the user reaches around 10 views of videos. Then, the provision of start recommendations will be stopped.

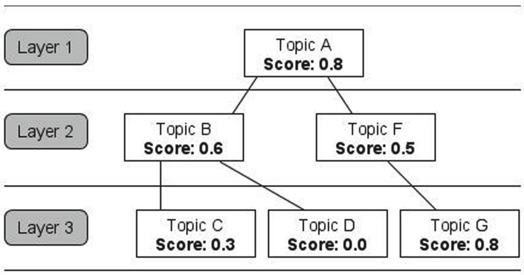

Fig. 3. Topic tree example with layers and scores

6 Evaluation

The presented concept was tested and evaluated in a first-term university course "Programming with Java". Although the course is compulsory, the use of the video platform is on a voluntary basis and intended as an additional blended learning offer. About 60% out of approximately 100 enrolled students use the learning video offer. In order to apply the presented concept, a questionnaire with 31 short questions was created based on the Topic Trees in order to ascertain the approximate level of knowledge. 28 questions relate directly to the topic tree and were rated using a 4-point Likert scale.

The two introductory questions focused on activities that learners pursued before their studies (question 1) and general programming experience (question 2: Do you already have programming experience?). Answers were highly heterogeneous: 18% of the respondents stated that they have no programming experience at all, but there were also just under 17% who, according to their self-assessment, have very good knowledge (score of 0.5–0.75). The other respondents had little (0.25) to medium (0.5) experience. It is important to note that the questionnaires were answered at different times and that there was no general starting day. This means that some students may already have enrolled on the first day of the lecture and others may not have enrolled until the middle of the semester. Here, of course, it is also possible that the level of knowledge has already increased. Especially on the different starting days, however, the necessity of an adaptive approach becomes apparent again, as it naturally makes little sense to teach basic topics to advanced learners. First insight indicate that the presented concept is well suited.

Compared to other languages (Python, C, C++, C#, PHP, JavaScript) relatively many of the beginners (81%) already had contact with Java (question 3: "With which programming languages have you already programmed?"). 19% had no experience at all with the language and are total beginners in this respect, in contrast to 11% with relatively high experience. The results of question 3 also show that an adaptive approach to learners is definitely necessary since different levels of knowledge are available.

As a sanity check, a "fake" question asked for experience with a non-existent programming language "E+". 13% of the respondents claimed at least little experience (score of 0.25). This could be due to two possible reasons: The questionnaire was not filled in seriously enough the individual recommendations could suffer if this affects all questions. Or the learner generally wanted to cover up a complete lack of knowledge, despite anonymity.

Overall, the start recommendations have so far been accepted by about 25% of learners. Further results are still pending.

In general, the benefits of these recommendations can be verified. In our video platform, each video can be rated in the last 5 s of the video on a Likert scale according to whether the video has been understood. 28% of learners who followed the startup recommendation rated the videos with a clear understanding of 100%. Only 1/3 of the learners rated the videos. This is not unusual and may be due to various reasons. For example, learners are not likely to rate a video if they did not watch it to the end, as they will only be asked to rate it at the end. A video is not watched to the end for several reasons, e.g. because the learner's problem has been solved earlier or the recommendation did not have the desired effect, but this was not investigated yet.

In summary, the results of the questionnaires indicate that heterogeneous learning groups are common and thus affect almost every teaching context. In spite of the small group of students, one out of four starting recommendations was accepted by the learners and 1/3 of them evaluated them exclusively with an understanding rate of 100%. Of course, the collected statistics cannot provide comprehensive evidence for the success of the concept but show that the concept was successful to some extent.

7 Conclusion and Summary

Handling heterogeneous learner groups in a learning context is very important because of the related success rate of the specific learning offer. A critical point is the introduction into a new field of knowledge. The way in which learners enter a new subject area can have a major impact on their further learning as the introduction should neither bore learners, nor frustrate them by being too easy or too hard. Less motivation or dropout is the consequence. Adaptive starting points for the introduction into a new topic could help to avoid these problems. In face-to-face education it is not realistic to analyze individual needs of learners to provide them more adaptive starting points, but in digital environments it is. The presented work may alleviate this problem by providing start-recommendations in video learning environments. An algorithm identifies start-recommendations based on user-questionnaire at course-entrance which may partially solve the startup problem. Recommendations are correlated with a so-called topic tree. Thus, learners get a specific and individual start (a selection of learning videos) for their learning path. Starting recommendations are tailored to the learners' specific needs, allowing them to enter a learning path as appropriate for their specific knowledge level for a given topic. Learners are not left to their own devices when choosing suitable entry videos, which may contribute to better motivation and lower dropout rates. We used an introductory course "Programming with Java" for a pilot study which is very well suited for the concept because of its many small topics. Thus, a meaningful tree structure could be created. Learners appreciate the concept, but there still is room for improvement. We cannot determine exactly what the learners liked or disliked because the feedback is based solely on rankings. The high degree of heterogeneity is confirmed by the questionnaires. Learners come with a wide variety of previous knowledge and prerequisites. Thus, adaptive learning paths, as presented in this paper, are necessary and essential.

In summary, the algorithmic concept depends on a well-structured tree and connected high quality questions. It is easier to derive good topic trees from more complex topics with many sub-topics. Topics with flat hierarchies or unrelated topics are only partly suitable for the use of this concept. After all, this concept also might establish a basis for using typical recommender systems in education since it provides an initial collection of data on knowledge levels and initial recommendations. This is expected to alleviate the typical cold-start problem in recommender systems.

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New Concept of Engineering Education for Sustainable Development of Society

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Abstract. The need to modernize the engineering education in the context of the transition to a digital economy has been substantiated. The drawbacks in the existing system of training modern engineers have been updated. The contradiction between the quality of training of engineers and the requirements of employers is revealed. Requirements for a modern engineer have been formulated. It is shown that a new model of engineering training is required to train an engineer of a new type that meets the modern conditions of sustainable development. Innovative engineering activity means the creation of technical facilities for a world free of hunger and epidemics, with open access to fresh water and information, to education for all, and to equality and sustainable development. It should be based on two guiding principles: competence to implement a solution and responsibility, to be aware of the consequences of this solution for the problem itself, as well as for the social, ecological and economic environment. On the basis of the revealed differences between the natural cognitive process and the structure of the existing engineering training, the concept of the natural structure of engineering training is formulated. Its main idea is that the educational process is an activity to develop the initial level of knowledge, skills and abilities of the student to the level necessary and sufficient for the implementation of a certain type of activity in technology. The structure of the educational process as an activity should coincide with the generalized structure of activity. Successful approbation of this concept on the example of continuous geometric-graphic training of students of a technical university allows us to hope that its implementation will help to form a new type of engineer.

Keywords: Sustainable development of society · Digital economy · Industry – 4.0 · Engineering · Engineering education · The concept of the natural structure of engineering training · Engineering pedagogy · Leonardo oath

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1 Importance of Modernizing Engineering Education

1.1 Basic Objective of Engineering Education

Now in the post-industrial world there is an understanding that new technological paradigm is not based on machines and technology, but on competency, on the abilities of a person with special skills, knowledge, working method. It must be able to transfer from their current area of work to the new, not provided with knowledge, and do it quickly and cost-efficiently. This is, in fact, a new generation of competencies. The main goal of engineering education is to help the engineers to do their work from the perspective of such categories as "sustainability", "professional development" and "environmental compatibility" [1]. The current level of development of information, communication and digital technologies allows us to implement the concept of the natural structure of engineering training as the basis for the development of engineering education [2].

1.2 Importance of Improving Engineering Education and Deficiencies in Engineering Training

Parliamentary hearings on the issue of technological modernization held in our country in recent years have come to the general conclusion: technological modernization of Russia is not feasible without the development and improvement of engineering education.

Globalization of markets and hypercompetition; rapid and intensive development of information and communication, digital, science-development, computer and nanotechnologies; global problems and blurring of research boundaries, their interdisciplinarity create the need for engineering training of highly qualified personnel. The transition from industrial society and simple technological operations to post-industrial economy and digital economy requires a large number of people who can work with packages of modern technologies in changing external conditions that force people to independently assess the situation and make responsible decisions. There is no alternative to the development of high technologies, interdisciplinary research, creation of world-class technical universities, and the increase of the importance of engineering professions. The necessary conditions for their implementation are government and economic support for engineering education, the distribution of young researchers to industry and universities, their formation as professionals, and the creation of proper motives.

According to employers and recruitment agencies, young professionals today lack professional skills, knowledge of the law and methods of creative solutions for engineering problems, motivation, focus on professional development and career advancement, preparedness for teamwork, the ability to present themselves and the results of their work in a professional environment. Among the disadvantages of university graduates there are: extremely low efficiency and productivity of engineering labor; lack of knowledge, skills and experience in using high-performance integrated computer network design tools (CALS); lack of knowledge of business procedures and features of the Russian business environment as a whole; lack of business communication and negotiation skills; lack of communication and representation skills; insufficient level of language training; lack of knowledge of methods for developing complex systems (synergies); as well as inflated requirements and ambitions that do not correspond to the level of training, the inability to assess their value in the market.

The existing system of training engineers is overall, mass, but not individualized, point-based, targeted, fully adequate to the specific conditions of the technosphere and the requirements of future employers. Universities, however, still organize their work so that graduates, first of all, have knowledge of the disciplines studied at the university (knowledge in the field of science; knowledge of design algorithms and technologies; knowledge in the field of general engineering disciplines).

The obstacles to improving engineering education in Russia include: low prestige of engineering education among schoolchildren; the outdated material and technical base of most technical universities; weak connection between engineering education and high-tech production; low motivation of young representatives of educators' staff; low activity of scientific research work of students; low percentage of practical learning (the classroom-lesson system prevails) [2, 5, 6]. Many companies and corporations are forced to create special educational courses for young engineers in order to eliminate their skill shortcomings. However, many employers are not satisfied with the way things are; they rightly believe that their aim is not to train engineers, but to hire. It is most relevant for small firms and companies, as they need the brightest engineers to "survive". Thus, there is a conflict between the quality of engineer training and the employers' requirements.

The understanding of the importance of modern technological innovations for the competitiveness of the economy determines new priorities for the engineering. The close interaction and interpenetration of research and the interdisciplinary nature of Industry 4.0 technologies determine the need to search for new paradigms of engineering. Global challenges (growth of population, growth and speed of consumption, scientific and technological progress, economic crisis, decentralization of the world, ecology and climate change, urbanization) change the engineer's role in the high-tech industry and society. A modern engineer must have a much broader range of core competencies, what changes the nature of engineering education in accordance with process requirements of the global digital economy [5–9].

1.3 Modern Engineering Requirements and Pathways to Innovative Engineering Education

Updating the methodology and contents of engineering education on the basis of modern science-development engineering approaches and the emergence of innovative digital economy allow us to move to innovative engineering education. The development of innovative engineering education should be carried out by comparing the best Russian and foreign educational programs, best practices, integration of modern science and technology, advanced industrial technologies and research results. A modern engineer must have a well-formed mechanism for making innovative solutions, have a high-quality level of education in the field of exact sciences and specialized subjects, possess computer technologies necessary for work, know and implement methods for searching information, system engineering and methods of activating creative thinking.

Implementation of practice- and project-oriented educational programs in the learning process will lead to the training of competitive professionals and the implementation of contemporary innovative projects that provide sustainable development and competitiveness of regions and countries; to the transformation of universities into centers of innovation, technological and social development of regions and countries [2, 10]. The implementation of the new sixth technological paradigm leads to the emergence of new scientific and technological fields. In the new technological conditions, the list of engineering professions and specializations will expand. The digital economy will further increase competition and, as a result, increase the rapid turnover of technologies in all areas of human endeavor as well. To maintain the competitiveness of the developed products, engineers must have a high level of qualification, innovative thinking, professional mobility and required motivation. Changes in the nature of engineering activities require adequate reflection in engineering training (ET) for industry [11–13].

It should be emphasized that the technique is getting better and more complex, and the knowledge of specialists is not enough. There is a lack of competence of operating personnel. The industry needs an engineer who is proficient in systems engineering; who has a deep knowledge of fundamental disciplines, systems analysis, modeling of complex systems, synergetics, theories of self-organization, decision-making; who is proficient in information technologies, including those that interact with human intelligence and are aimed to develop its intellectual abilities, project management.

1.4 Leonardo's Oath for Engineers as Guideline for Their Training

Considering the UNESCO millennium goals, the idea of creating (similar to the Hippocratic Oath in medicine) "Leonardo's Oath for engineers" as the main goal of engineering education sets the requirement that engineers perform their work based on the categories of "sustainability", "professional development" and "environmental compatibility". The Leonardo oath was developed as a reference point for engineering education programs with the understanding that engineering is not just a process of transferring technology into products and solutions. It is designing and influencing life on earth [1, 14]. So engineers must understand the theory and practice of their discipline – but they must understand too: what technical solutions will be the need for a stainable-based development of the future and what happens really in the moment, that their solutions will become reality (what kind of resources will be used, what are the effects for the labor-market, how is it possible to combine or lost advantages for the economic value of the solution).

So engineering activity is such type of work, which need a high quantum of "professional training competence": developing several variations of a solution is necessary to understand that there is no ideal solution in the trend of social and environmental responsibility and economic structure. But it is the response of engineers has to show what is more stable, what is possible, what is responsible and what is necessary to discuss and to reflect into the world of globalization and networking according to the aim supposing to develop at least a product or service-offer, which is near to the optimum. So the "Leonardo's Oath" contains the requirement to all kinds of engineering education – to develop a good professional training competence.

In conclusion, the main thesis of this document is that engineering means creating technical facilities for a world without hunger and epidemics, with free access to fresh water and information, to education for everyone, to equality and sustainable development, so engineering should be based on the following two guiding principles: competence in implementing the solution; responsibility, awareness of the consequences of this solution for the problem itself, as well as for the social, ecological and economic environment. This means that the main aim of engineering should be implemented as a dualistic function. Its ethical component is oriented towards the future regarding the situation in the world. [15–17]. Each engineering course should be based on the idea that engineers will be prepared to use the acquired technical knowledge with their responsibility for design, focused on the principles of the ethical justification, sustainability and social assessment. Curricula in engineering education should give more freedom in courses for practice-oriented training, solving engineering problems. The typical structure of such a course shows [1, 18] that, in the case of development of design competence, academic courses should follow the principle of the action taken with the steps "inform, plan (decide), do, control, analyze", which correlates with the CDIO concept of the Massachusetts Institute of Technology.

2 The Concept of the Natural Structure of Engineering Training (Natural Learning – NL) as the Basis for the Development of Engineering Education, Its Main Provisions and System-Forming Theses

2.1 The Main Differences Between the Natural Cognitive Process from the Structure of Existing Engineering Training

The main differences are between the natural cognitive-educational process and the main features of a typical, artificially synthesized structure of domestic engineering training, which is still being implemented by the traditional basic educational program, one way or another, preserved as a platform for official innovations held in recent years [1, 2, 19].

1. The natural cognitive process begins with a complex of sensations from "communication" with the object and the physical processes of a given subject area as a whole, gradually dissecting, differentiating them, passing to some models of the object (process), highlighting in an explicit form sequence of analytical steps. The artificial educational system (AES) (or the traditional Russian system) implies the advanced study of models of the abstract level (mathematics, physics, and other theoretical disciplines), i.e. the study of models in AES is ahead of the study of a simulated object or process.
2. Natural cognitive-educational cycles in the natural structure of engineering training (Natural occurring leaning – NL) are consistent with successively arising types of activity in technology, relying on the logic of gradual "penetration" into the essence and characteristics of an object (process) through its increasingly detailed description. The curricula of engineering training in AES are built on the principle

of a sequential transition from natural sciences to general technical and professional for a given area, and then special, thereby delaying the knowledge of a specific object area and activities in it for a long time.

3. In the natural educational process, the leading goal is to identify the relationships of the internal parameters of an object (process) with its external parameters - quality indicators (usually contradictory, complex and integral). In the framework of classical technical theories and disciplines, quality indicators are rarely distinguished as controlled integral parameters. Moreover, they are rarely considered as conflicting factors that define technical contradictions.
4. In natural practice, a technical object (process) is one, as a carrier of the level of intellectual, technological capabilities and values of its time and, due to the objective specificity of human perception of the surrounding reality, is perceived and evaluated by a person objectively but subjectively. In AES, in technical disciplines, as a rule, only utilitarian-metric characteristics of objects (processes) appear. The subjects of the socio-humanitarian cycle contain only subjective-value characteristics, but, unfortunately, other objects. The natural two-pronged perception of the objective world is destroyed.
5. The natural transformative-educational process is characterized by conflicting statements of tasks, the presence of conditions and limitations, the constant problems of conscious choice of workable alternatives. A typical educational process is based mainly on the non-conflict solutions for solving educational problems, and the choice, as the most important element of real activity, is practically reduced to the choice between a mistake and the only correct result.
6. In general, the traditional structure of engineering training is initially aimed at synthesis, ignoring the analysis stage, which is mandatory for the process of cognition. Existing structures are focused on synthesis because engineering training begins with a cycle of natural science subjects – theoretical disciplines that operate with high-level abstract models and differentiated representations, and not with the decomposition of the whole (here it is not the general and the particular, but the whole and the part).

In addition, it should be noted that at the stage of general technical and, especially, special professional education, it is necessary to re-learn, on applied material, the methods and approaches of previously studied fundamental disciplines, especially higher mathematics, physics, mechanics, etc., which is direct as a consequence of their formalized education without constant support for applied needs.

2.2 The Main Provisions of the Concept of NL and Its Basis Thesis

The feasibility of any educational paradigm implies its concretization on the basis of structural, constructive, technological and parametric descriptions (however, like the realization of all that is artificial and the description of the natural). Without specifying the sources, it should be mentioned that not often a critical analysis of the state of higher technical education ends by proposals that claim additional explanation for their implementation. The NL fractal structure generator is an invariant activity structure (see Fig. 1), the main elements of which coincide with the design structure.

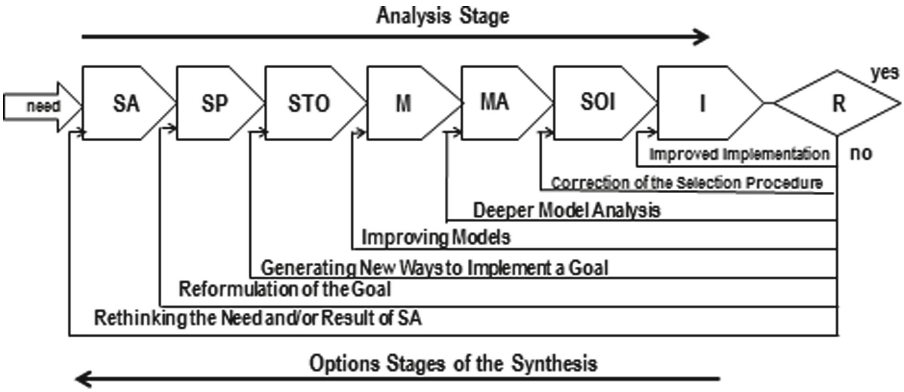

Fig. 1. Generalized structure of activities.

SA – System Analysis, SP – Statement of Purpose, STO – Sorting Through Options, M – Modeling, MA – Model Analysis, SOI – Selecting an Option for Implementation, I – Implementation, R – The result is achieved?

The sequence of stages “from left to right” (see Fig. 1) corresponds to the analytical stage and without correction represents the structure of reproductive activity. Corrective reverse cycles – with one or another adjustment (see Fig. 1) and again “from left to right” determine a productive (synthetic) transforming practice within the framework of this target activity.

The projection of this generalized structure of activity on the educational process defines the main system-forming theses of NL:

1) the educational process is also an activity and must follow the general logic of activity; at the same time, the logic of the formation of knowledge, skills, abilities for this sphere of activity will correspond to the logic of the activity itself due to the invariance of the generalized structure (see Fig. 1) (the structures of the formed and formative activities coincide);
2) at the analytical stage, the traditional didactics of the development of concepts, is more important; on the synthetic (at the stage of correction of the reproductive variant) design didactics (theory of design activity) should prevail. This, of course, is true at every educational level;
3) any local (private) educational cycle (for example, setting and solving an intra-objective problem) must follow the general logic of activity, determining the fractal dimensions of the educational structure NL (end-to-end uniformity of logic);
4) such a logical structure of the educational process will correspond to the logic of the student’s activities outside the educational process; both areas of his activity on logical organization will not contradict, but complement each other. The second structure-forming factor of NL is the historical logic of the successive emergence and development of professional activities in technology, formed and “formed” in the order as in Fig. 2 (of course, this is the spatiotemporal averaging of this sequence, indicated from the bottom up).

On the right, for each type of activity, descriptive signs of technical objects (processes) that are minimally necessary for it are indicated.

These signs become more complex and expand (integrate) as you move to later emerging activities. The order of mentioning from bottom to top corresponds to the natural sequence in the analysis of realizations of process, i.e. studying this type of activity and, accordingly, expanding the descriptive "language" necessary for this. From top to bottom is the sequence of applying knowledge, skills and abilities in the creative synthesis of new objects or processes. The image of the object highlighted in Fig. 2 is its presentation form, with which the analysis begins and the synthesis of technical object ends.

The demonstration of the logic of the historical development of types of equipment to the structure of engineering training, which is the logic of the natural extension of the descriptive attributes of the technical object (deepening "penetration" into the object) within the framework of this educational model, involves the addition of the basic theses of the NL structure as follows:

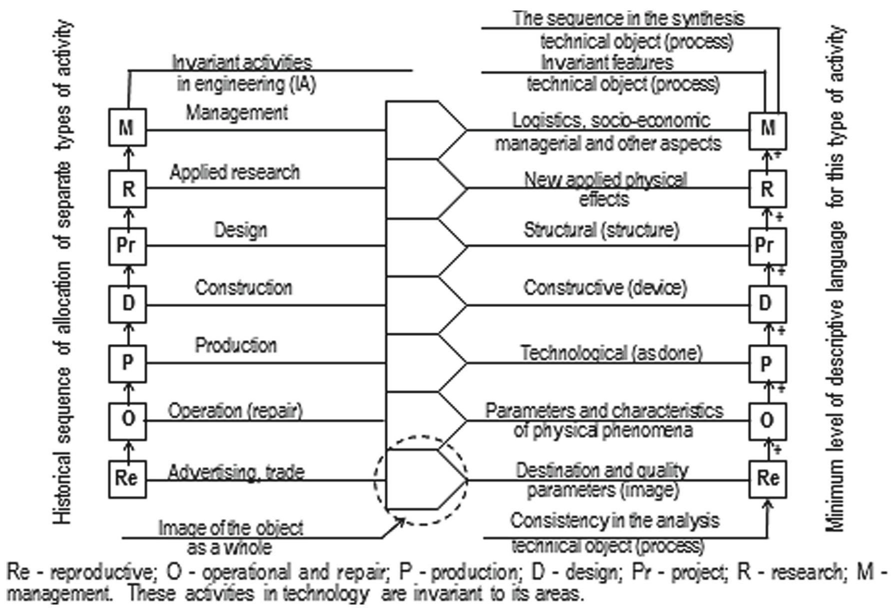

Fig. 2. Averaged historical sequence of registration of specific activities in technology (from bottom to top) and a sequentially integrated level of descriptive attributes of an object (process), i.e. depth of description required for this activity.

5) the natural educational process of preparation for activities in a certain area of the techno-sphere should be based on the gradual (sequential) complication of the descriptive language at all stages of educational activity in accordance with the logic of the occurrence of engineering activities;

6) in particular, the disciplines of the natural science cycle should be modeled by applications, integrating at the highest level of the NL structure. The structure of the training course of this discipline in the framework of engineering training in NL (and not academic) and its structure as a scientific one are different. For NL, it is structured by application and integrated at the final stage of preparation. The scientific discipline itself is naturally built and developed according to its internal logic. At the same time, the educator should know the discipline in development as a scientific one for a conscious and creative application, especially at the synthetic stages of educational activity. Finally forming the structure of the NL concept, we present in Fig. 2 each type of activity with an invariant structure (see Fig. 1) and obtain the structure as in Fig. 3.

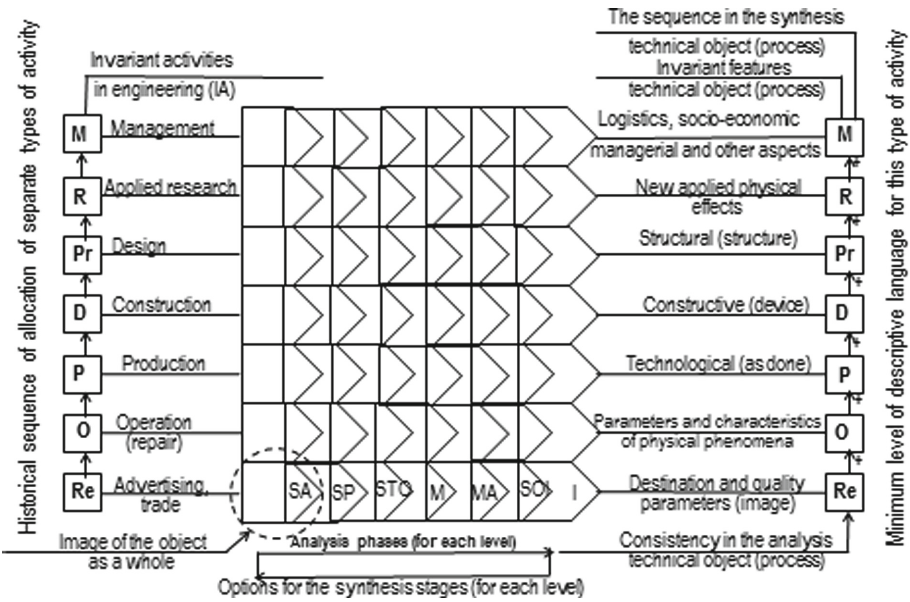

Fig. 3. The generalized structure of the formation of the basic educational program of engineering training in accordance with the logic of natural intersubject communications

The implementation of the educational structure NL allows, while maintaining fractal dimensions, different trajectories on the structure (see Fig. 3). For example, the "analysis-synthesis" cycle can be provided sequentially at each activity level (as shown in Figs. 1, 3) or carried out through the analytical stages of the branch to the upper level, and descent along the synthetic branch.

It is necessary to supplement the comparison of the structures of engineering training traditional for Russia and naturally arising from the universal transformative-cognitive experience. From the structure in Fig. 3 it follows that the disciplines that operate with models of a high level of abstraction (fundamental), NL suggests shifting closer to the final cycle of preparation.

It is known that the traditional argument for the thoroughness of the domestic system of higher technical education is based on its fundamental nature. It is understood and interpreted literally. But after all, the foundation itself must rely on solid soil. In the traditional position of the disciplines of the natural sciences cycle, they are studied without the support of immediate need, and at the stage of special disciplines they are practically re-mastered on applied material. Fundamental should be the outcome of the training as a whole, as NL suggests.

The clarity of the structure allows you to clearly profile the training and creates the prerequisites for programming and automation of the preparation of curricula. Its structure is fractal from the methodology for solving a particular problem to the methodological portrait of NL itself.

The main objective features of NL, which determine the problems of its implementation, as can be seen from Fig. 3, are in the initial stages of the preparation of the natural sciences cycle they imply an accented applied beginning, moving to abstracted models as preparation approaches its final stage. This requires the expansion of interdisciplinary erudition of educators, the unification of terminology, and ideally, a wider division and enlargement of departments according to their activity (there are, however, partly corresponding to this department "operation…", "technology…", "design…"). The educational process involves greater fragmentation, the submission of disciplines in portions in accordance with the stages of the model of this activity.

Looking at these points above, modern engineering education should be action-oriented, which means: not revising theoretical knowledge is the main topic of learning. The main idea is to give students a problem to solve. Thus, they must understand the problem and must find solutions – and they will learn theory from examples with a direct link between practice and theory. This part is a deductive way of engineering training. Second effect: they will provide a decision, at which point the academic educator can start with the reflection process as the core of the engineering education process.

2.3 Fundamentals Points of Projecting of NL and Its Main Innovative Components

Summing up the above, it is necessary to say that the following provisions are the basis for constructing the natural structure of engineering training NL [1, 2, 19]:

1. The logic of any human activity can be represented by a generalized structure that is invariant to the form and sphere of human activity, including in technology. Any activity is initially designed, so the structure of its stages coincides with the design structure and is supplemented only by the implementation stage.
2. The educational process is an activity to develop the initial level of knowledge, skills and abilities of a student to the level necessary and sufficient for the implementation of a certain type of activity in technology.
3. The structure of the educational process as an activity should coincide with the generalized structure of the activity. The main innovative components of the

concept of the natural structure of engineering training NL, allowing engineering training in the format of modern information and communication technologies and digital technologies, include:

- the presence of a system-forming idea;
- the objectivity of its generating structural core;
- consistency with the structure of natural stages and the logic of the cognitively transforming function of human activity;
- consistency with the natural processes of perception and cognition by a person of the surrounding world;
- the crosscultural nature of the basic principles of the natural structure of engineering training as a prerequisite for simplifying communications in the field of technical education;
- the end-to-end fractal nature of the natural structure of engineering training, including structures for solving particular educational problems that coincide with the structure of the student's life;
- algorithmicity as the basis for comprehensive informatization of the educational process;
- organic formation of any range of competencies;
- the invariance of the structure to preparation in any field of technology and the type of activity in it.

This concept has been tested on the example of continuous geometrical-graphic training of technical university students [19].

The main task of our universities is scientific, technical and personnel support for the modernization of high-tech industries, and training for the future engineering and technical elite. Therefore, the issues of quality of training of engineers, advanced ideas in the field of engineering education are traditionally the priority for us.

3 Conclusion

1. We would like to maintain the system of soviet engineering education, which was traditionally strong in training creative specialists, since their thinking was formed on the basis of the systemic educational principle "from general to particular".
2. Industry 4.0 needs a specialist who owns system engineering, information technology, project management; possesses deep knowledge in the field of fundamental disciplines, systems analysis, modeling of complex systems, synergetics, theories of self-organization, operations, decision making, etc.
3. For the successful implementation of the goals and objectives of the digital economy fundamentalization of education, the creation of conditions for the implementation of the principles of individual training engineering in the digital economy is necessary.

4. The implementation of the proposed concept of engineering education based on the natural structure of engineering training and the code of professional engineers "Leonardo's Oath for engineers", in our opinion, will help to form a new type of engineer, competent in the implementation of the decision and responsible for the consequences of this decision for the social, environmental and economic environment.

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Ontological Visualization of Knowledge Structures Based on the Operational Management of Information Objects

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Abstract. The properties of ontological models to reflect the conceptual view of a researcher on a certain subject area and uniquely determine its concept, structure, accumulate and reuse knowledge repeatedly and make it possible to widely use it in the educational process. However, the existing tools for constructing ontological models of ontology knowledge (Protégé in integration with OWLViz, OntoGraf, 3D Hyperbolyc, Tree, TODOS, etc.) only partially satisfy the needs of the educational process. The choice of a particular visualization method is specific and has its own characteristics depending on the task. When choosing visualization tools, it is important that they do not only help to effectively reflect all the information, but, at the same time, allow the user to perform easily various operations on ontologies. There is no single definite method that is universal. The article describes the author's web resource https://ontos.xyz, designed to create and visualize the hierarchical structure of subject areas using an ontograph, is implemented as a combination of content-containing concepts (vertices, nodes) and the relationships between these concepts. The authors determine the possibilities of using the ontological approach in the pedagogical process by the example of working with the web resource they created, which provides convenient use of ontologies. The article discusses examples of using ontologies to provide semantic annotation for collections of images, sound and other non-text objects; for the development of documentation of arbitrary volume; for building directories with the ability to support the surjective connection of objects (nodes); to simplify the performance of search work, etc. The purpose of the article is to reveal the features of the use of ontological structures for visualizing knowledge schemes and components of the operational management of information objects.

Keywords: Ontologies · Knowledge bases · Remote education

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1 Problem Statement

Knowledge is an integral part of any educational process. In connection with the current situation in the world related to the viral pandemic, the question of introducing remote forms of education is extremely acute. Their usage involves the indirect interaction of a teacher and a student with the help of many forms of communication provided by the capabilities of modern Internet technologies. In connection with the current situation in the world related to the viral pandemic, the question of introducing remote forms of education is extremely acute. The use of remote forms of education involves the indirect interaction of a teacher and a student with the help of many forms of communication provided by the capabilities of modern Internet technologies. Consequently in recent years, there has been a growing interest in semantic technologies that provide the ability to implement automated processing of conceptualized knowledge [1, 2]. An important component of such technologies is the technology of ontological representation of knowledge, which allows the creation of formalized electronic models of knowledge through ontological modeling.

2 Analysis of Recent Research and Publications

Today, there are many definitions of the concept of "ontology" to varying degrees, reflecting the semantic content of this phenomenon. In the framework of this work, we will use the definition proposed in 1996 by van Heinst and his colleagues: "An ontology is an explicit knowledge-level specification of a conceptualization, e.g. the set of distinctions that are meaningful to an agent. The conceptualization – and therefore the ontology – may be affected by the particular domain and the particular task it is intended for" [3].

3 Statement of Basic Material and the Substantiation of the Obtained Results

The properties of ontological models to reflect the conceptual view of a researcher on a certain subject area and uniquely determine its concepts, structure, accumulate and repeatedly use knowledge allow them to be widely used in the educational process. Obviously, any subject area is a subset of the general information space - the universe. It is indicated by the symbol U in the constructed diagram. The subject area P, which is a subset of the universe, defines a certain scientific theory, the study of a certain part of which should be provided by the textbook T. The part (subset) of the subject area, the study of which is intended to provide the textbook does not limit the content of the textbook to 100 percent. To describe the concepts of subject domain P, the textbook should use data from other subject areas (let's call them auxiliary), which, in turn, are subsets of the universum (Fig. 1).

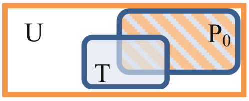


Fig. 1. Venn diagram of the sets of the textbook T and the subject area P_0 studied with its help.

These areas include the concepts of related and serving sciences. For example, consider the second Faraday law. He determines that for a certain amount of electricity, the mass of the chemical element formed on the electrode is directly proportional to the equivalent mass of the element. It is equal to the mass of one equivalent – the amount of substance that reacts or replaces 1 mol of hydrogen atoms in chemical reactions: μeq = μ/z, where: μ is the molar mass of the substance; z is the number of electrons per ion (valence number of ions).The concept of molar mass is studied at chemistry lessons and refers to the subject areas of both educational subjects (both chemistry and physics). The mathematical actions that are used to describe the formula representation of laws are determined by mathematical terms, the order of presentation of the material, its content is determined by laws (and, therefore, the terms of didactics), etc.

Another example of the usage of different subject ontologies within the same textbook is a retrospective of the history of various discoveries, fragments of biographies of scientists, etc. Some authors use the concept of metaontology, meaning by this concept either a kind of "connecting" ontology, for example, an ontology of the "human" language for describing a subset area, or an ontology for which domain ontologies used to solve a particular problem are subsets. So, for example, G. Evgenev indicates that metaontology operates with general concepts and relationships that are independent of a specific subject area. The subject ontology contains concepts that describe a specific subject area and the relationship between them. The task ontology contains functions with the help of which the input data are converted into output data [4]. Thus, the textbook can be represented as the intersection of the sets of terms of interconnected subject areas (Pi, i = $\overline{1,n}$): T = $\bigcap_1^n P_i \neq \varnothing$.

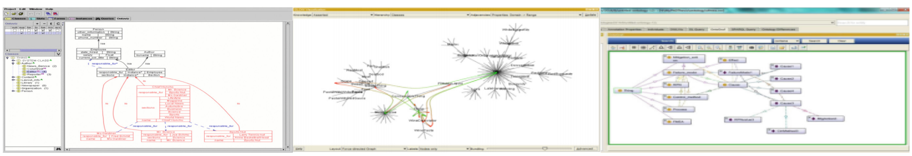
Let us represent each of the subject areas used in constructing the textbook in the form of an ontological model. To do this, we describe the ontology by mathematical methods. A formal description of an ontology in the form of a triple is considered classical [5]: O = <X, R, F>, where O, in fact, ontology; X = {x1, x2,… xn} is a finite set of domain concepts, and n is the number of elements in this set; R = {r1, r2,… rm} – a finite set of relations between the concepts of the subject area, m – the number of significant relations; F – is a finite set of interpretation functions defined on concepts and ontology relations O [6, 7]. F is the Cartesian product X × R is a finite set of interpretation functions defined on concepts and/or relationships.

In the general case, relations can be conditionally divided into generally significant (of which, as a rule, relations of a partial order are distinguished) and specific relations of a given subject area. In fact, the relation R is an interpretation of the properties of concepts, that is, there is a transformation that each relation establishes a correspondence of a certain property. Let us depict the triplet graphically. In the boundary case, n = 1, respectively, the number of significant relations in the set R (taking into account the void X × R) equals to 1, and the triplet corresponding to such an ontology can be uniquely determined using a simple ontograph (Fig. 2).

Fig. 2. The simplest ontograph

Since the relation uniquely determines the dependencies of concepts, the edge of such an ontograph always represents a directed segment. In the ontograph depicted, the "Swallow" peak is a daughter, with respect to the "Bird" peak. In this ontograph, the relationship defines the standard relation "is", or, in other words, "one of the elements of the set". Building an ontological model allows to specify other dependencies, for example, expressed by the words "more than" or "coincides with an accuracy of similarity coefficient". Thus, a combination of the simplest ontographs, between which nodes dependencies are also defined, allows you to build an ontological model of any complexity.

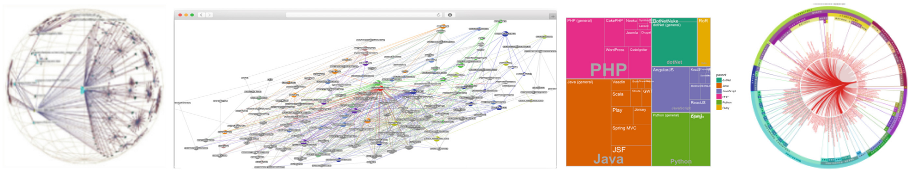
Currently, there are numbers of tools for creating and supporting ontologies that, in addition to the general editing and viewing functions, support ontology documentation, import and export of ontologies of various formats and languages, support graphic editing, manage ontology libraries, etc. [8]. Obviously, the manual should provide an explicit statement of knowledge in its subject area, and therefore the use of scientifically based methodology, such as ontology, is necessary [9]. One of the most widespread, and therefore demanded, is the development of Stanford Center for Biomedical Informatics Research at Stanford University School of Medicine called Protégé. Protégé is a tool that allows to create a domain's ontology, custom data entry forms for data entry. Protégé allows to define classes, class hierarchies, variables, variable constraints, and relationships between classes and the properties of these relationships. Platform-integrated applications allow ontologies to be displayed in various ways (Fig. 3).



a) b) c)

Fig. 3. Ontology tools for displaying in Protégé: a) OntoViz; b) GlowViz; c) OntoGraph

The existing ontology construction tools are not limited by the Protégé platform and only partially satisfy the needs of the educational process. So in the line of visualization tools you can select 3D Hyperbolyc Tree - it builds an ontograph tree in hyperbolic space; Conceptino – is a visual graph designer that organizes large amounts of information into graphic schemes; tools for creating “flat trees”, for example, the resource https://www.anychart.com; SciVi scientific visualization system with the installed CGraph application (Fig. 4).



a) b) c) d)

Fig. 4. Visualization tools for ontographs: a) 3D Hyperbolyc Tree; b) Conceptino; c) Anychart; d) SciVi-Cgraph

All these visualizations have one common specific feature, which is often very convenient, and even necessary for research: the relationships between all objects are displayed (or all objects are shown at the same time, as in Anychart), but, as we can see, all the proposed implementations ontology mappings are quite far from the kind of electronic textbook familiar to participants in the educational process.

Unfortunately, in relation to the educational process, this approach is far from being always justified. With a sufficiently large number of connections (typical, for example, for school textbooks), the screen becomes cluttered with elements that are unnecessary for immediate work and, therefore, elements that are harmful to the perception of educational material.

Let us give an example of an image of sufficiently large ontographs with obvious redundancy in the display of elements (Fig. 5).

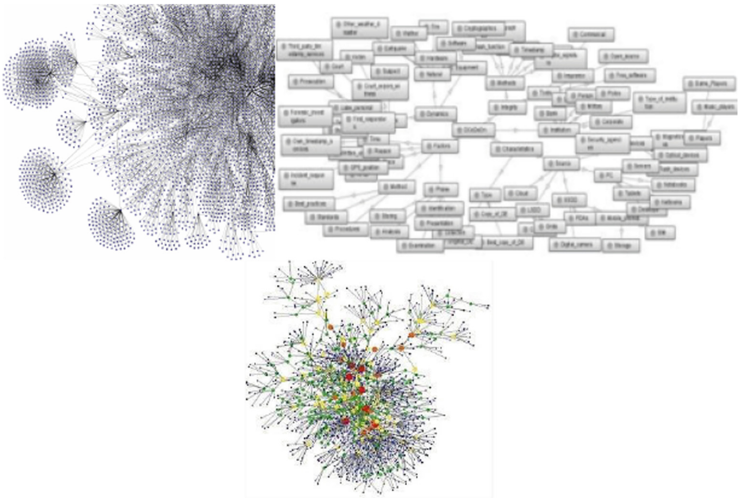


Fig. 5. Examples of displaying ontographs with a large number of connections

One of the tools of visualizing ontological models, where a breakthrough in improving usability was made, was the development by VAH of Ukraine of TODOS (TODOOS) – a system with a powerful user interface focused on various research and other tasks [10] (Fig. 6).

Fig. 6. Various variants of the TODOS user interface

One of the successful solutions of the problem of clutter of visualization was the development of the Minor Academy of Sciences of Ukraine - the ontological prism presented in the systems TODOS (Fig. 7) and AgrOn [11].

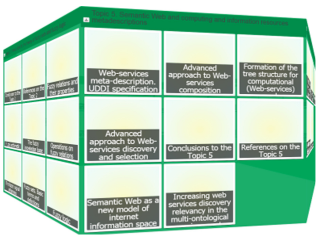
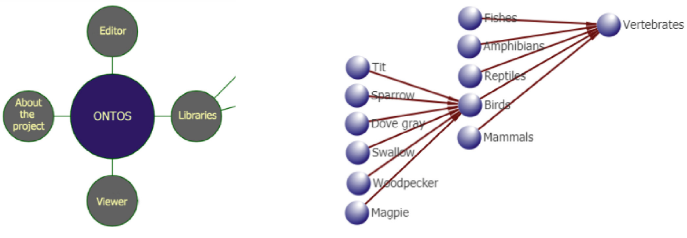


Fig. 7. Ontoprism in Todos system

Being one of the most convenient tools for displaying an electronic textbook, ontoprism is a special case of the visualization system, which consists of two components: a navigator that determines the path to some node of the ontograph that has child elements and a visualization slider for this node that displays these elements. When one clicks on the display of an element on the edge of the prism, a pop-up window for the content of each element appears, which can contain text, a picture or a hyperlink. A navigator can be an ontograph, a tree, navigation buttons, hyperlinks, etc. Its main goal is to determine the node which visualization will be carried out.

Indeed, when working with a familiar textbook of the “ordinary” or “paper” type, a participant in the pedagogical process, as a rule, does not constantly observe the path to the current page (content) of the textbook.

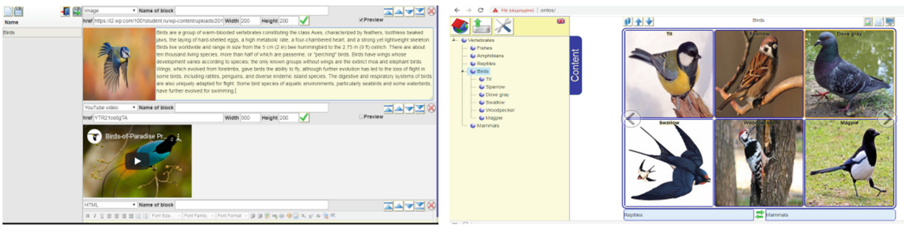
While agreeing with the proposed approach, though we feel like to note that the proposed platform, being a research tool, does not fully meet the needs of the educational process. First of all, it is not provided on the pages of arbitrary formatting content, there is no possibility of introducing feedback, there is no compatibility with web 2.0 technologies, etc., without which it is difficult to imagine a modern electronic textbook. Based on the foregoing, the task arose: to implement an ontological approach in relation to the actual creation of an electronic textbook that would correspond to modern capabilities. To achieve this goal, an online resource https://ontos.xyz/ (Fig. 8) was developed consisting of an editor and a viewer.



a) b)

Fig. 8. Ontos project: a) the main page; b) an example of an ontograph

Like many systems, the editor is designed to create an ontograph. The main feature of the editor is the ability to assign each node a context of all types supported by the browser. Including html-pages, web 2.0 resources, etc. (Fig. 9a). The second distinguishing feature of the development is the maximum approximation of the displayed node to the familiar textbook (Fig. 9b).



a) b)

Fig. 9. Context creation management window

The fully implemented principle of the two-component ontograph display technology is the presence of content with hyperlinks to transitions to individual vertices and, separately, a navigation system with transitions to neighboring (single-level, parent and child) nodes.

4 Conclusions

With the advent of the semantic network and semantic technologies, ontologies have emerged that have become one of the most sought after paradigms for representing knowledge. Ontological models reflect the conceptual view of a researcher on a certain subject area and provide an opportunity to uniquely determine its concept, structure, accumulate and repeatedly use knowledge. A number of scientists define the following ontology functions in education: simplification due to automatization and systematization of students' search for information on the chosen research topic; providing students with the opportunity to analyze and compare information within the chosen topic due to the clear structuring of information; the development of new information by students on the basis of knowledge gained for further use in independent research; activation and effective use by students information resources of a society about a given subject area; expanding one's worldview, as it simplifies the opportunity to get acquainted with related concepts that go beyond the standard course; increasing student motivation to study. Presentation of information in the form of an ontological model with a two-component display allows to display individual information concepts (terms, concepts) in a convenient form for the participant in the educational process and get a lot of their semantic connections with other objects, thereby understanding their role in this knowledge system or in solving the problem.

The ontological approach to education cannot be just a means of organizing knowledge. Expanding the traditional functions of software that works with ontologies, one can create an information environment in which active work with knowledge is provided, and educational tasks are also solved in an original way.

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Developing Teacher Professional Competency Under the Integration of Russian Universities into the World Academic Area

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Abstract. The article notes the importance of studying the interconnection of professional competency and integration processes in higher education for their subsequent use in the development of competitive higher education. The research objective is to identify the key competences of University scientific and pedagogical staff as an integral part of professional competency influenced by internationalization and integration of Russian universities into the global educational area. To rich this objective the authors put forward the principle of convergence. In the process of convergence, all ideas and concepts are aligned, penetrate each other, diffuse thus enriching each other. The authors also highlight the difference between "competence" and "competency" and define teacher professional competency is a result of acquisition or developing a set of competences getting through experience in various fields including professional area. Teacher professional competency is a part of teacher professional excellence. The foundation for teacher professional excellence is provided by the hierarchical structure of the individual which has three levels. Teacher professional competency correlates with the second level of the hierarchical structure of a person which in its turn consists of: 1. individual knowledge, 2. skills (competences), 3. acquired skills, 4. habits. The authors define four levels of individual knowledge development and classify skills by orientation, by levels of organization of activities and by levels of acquisition. Using theoretical studies the authors have already developed the IDUTE programme (International Dimension of University Technical Teacher Education) designed to enhance the international dimensions of various components of university teacher education programmes, to transform courses in order to facilitate change and improvement in reaching internationalization goals of their work and to help provide university teachers with greater global knowledge and competences.

Keywords: Internationalization · Integration · Higher education area · Competences · Teacher professional competency · Teacher professional excellence · The principle of convergence

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1 Introduction

The activities of scientific and pedagogical staff have changed greatly in recent years. The professional competency of a modern teacher is modified being influenced by the processes that determine the development of higher education in the late XX–XXI centuries. An important factor affecting the professional competency of University teachers is the process of internationalization and integration of Russian universities into the world academic area. The relevance of the study of professional competency in the context of internationalization and integration is confirmed by the need of universities in qualified specialists in the field of international cooperation, the development of scientific and educational collaboration with foreign partners, and promotion of universities in international rankings. The article notes the importance of studying the interconnection of professional competency and integration processes in higher education for their subsequent use in the development of competitive higher education.

2 Project Description

2.1 Purpose

The research objective is to identify the key competences of university scientific and pedagogical staff as an integral part of professional competency influenced by internationalization and integration of Russian universities into the global educational area.

2.2 Approach

Understanding professional competency implies the need to select the principles essential for acquiring the necessary knowledge. And the first principle we put forward is the principle of convergence. Studying the phenomenon of convergence, A.S. Arsenyev comes to the conclusion that “convergence consists in the fact that if you seriously delve into the philosophical, religious, mystical, mythological teachings of both the West and the East, you begin to notice a certain alignment of all these teachings and ideas of a man about the world and about himself. In all these teachings and reflections there is the attempt of a person to define himself in the world and in his relationship with the World as a whole” [1]. As you go deeper into a problem, you begin to notice the convergence of your path with other paths and, consequently, the convergence of your ideas and thoughts with the ideas and thoughts of other people: the thoughts and ideas that you have might have already come to other people though for some other reasons. For a person moving in the flow of convergence, the discovery that others have already passed here before you, or have come close to it, and discovered the same ideas, is accompanied not by disappointment, but other way around, that is by joy. When a person comes to some ideas that at first seem to be his own personal discovery, and then suddenly finds that people have already expressed these ideas two thousand years ago, he understands that he is moving in the right direction, in some huge flow of universal development. That should bring him satisfaction and joy. “Convergence is not a formal generalization, but rather the opposite process.

Generalization means that objects or phenomena are put together because they have similar features. Those feathers that make these objects or phenomena differ from each other are in this case ignored. A generalizing concept is always poorer than the content of the concepts that it generalizes. In the process of convergence, all ideas and concepts are aligned, while each of them does not lose its specificity and completeness of its content. These contents begin to converge, penetrate into each other, diffuse thus enriching each other" [1]. In the next paragraphs we will identify the levels of convergence.

The lowest level is that of dispute. This dispute can take different forms, up to the physical destruction of each other. For example, the wars between Islam and Christianity. The goal of a dispute is always self-affirmation by refuting or defeating the opponent. The next is the dialog level. In contrast to a dispute, the parties in a dialogue try not to refute each other and thereby assert themselves, but to find a common truth. Therefore, their dialogue can be fruitful and the search for truth can result in some (temporary) success. Any dialogue is a way to the "objectivity" of truth independent from the will and consciousness of not only the disputing parties, but all people in general. And the parties of the dialogue try to reach agreement in understanding and perception of this truth. The higher level that follows the level of the dialogue is associated with an awareness of the personal nature of the truth. At the same time, the objectivity of truth does not disappear, but it becomes a secondary, subordinate moment. Personality, its originality, its own special vision, perception and feeling of truth are more important than the objectivity of this truth, that is, its independence from the individual. Here, the conversation about truth begins to lose the form of a dialogue. Just in conversation or in communication, everyone shares their understanding and perception of the truth. At the same time, the understanding and perception of the truth of one enriches the other's idea of it, and vice versa. Everyone remains free in their individual-personal perception and understanding of the truth. The next, higher level is the level of diffuse consciousness. At this level, consciousness can already take a position of non-necessity in relation to some points of view or teachings. All of them are represented as a kind of diffuse field in which they are more or less dissolved and penetrate each other. But in order to solve of a certain task or to carry out a research, consciousness can "snatch" from this general diffuse field a certain religious or philosophical teaching that is most suitable for the solution of the task. The last level is the level of mystical experience. It is so unusual that all great mystics who achieved it spoke of the practical impossibility of describing it in ordinary words and images. A positive, unambiguous description of this level is not possible as it comprises mutually exclusive epithets or concepts (known as oxymorons).

On the lowest level of dispute, it is impossible to understand teacher professional competency as there are a lot of point of views on this issue. That's why we try to engage in a dialogue with researchers who investigated teacher professional competency and enrich the other's idea of it, and vice versa.

3 Literature Review

First of all, we would like to highlight the difference between "competence" and "competency". We define teacher professional competency is a result of acquisition or developing a set of competences getting through experience in various fields of professional area. Teacher professional competency is a part of teacher professional excellence. The foundation for teacher professional excellence is provided by the hierarchical structure of the individual [13]. The top level is the orientation of the individual: worldview, values, beliefs, aspirations, etc. The second level is experience of a person: knowledge, skills (competences), skills, habits. And the third level is higher mental processes: intelligence (thinking, memory, attention), will, emotions, physical (motor) activity. Teacher professional competency correlates with the second level of the hierarchical structure of the individual.

Competences in their turn have a lot of definitions. Some researchers define them as "the set of knowledge, skills, and experience necessary for future, which manifests in activities" [8]. Gupta [5] define competences as "knowledge, skills, attitudes, values, motivations and beliefs people need in order to be successful in a job." We can't agree with the author as we consider that attitudes, values, motivations and beliefs are not competences but orientations of a person.

The common understanding related to teachers' competences is divided into three main areas as field competences, pedagogical competences, and cultural competences. Teachers' professional competences can be composed of different dimensions other than the three main areas as stated in Papers [2, 3, 6, 7, 14, 15, 17].

Pedagogical competences, for example, can include the following competences: 1) effective classroom management, maximizing efficiency, maintaining discipline and morale, promoting teamwork, planning, communicating, focusing on results, evaluating progress, and making constant adjustments. A range of strategies should be employed to promote positive relationships, cooperation, and purposeful learning. Organizing, assigning, and managing time, space and activities should ensure the active and equitable engagement of students in productive tasks. 2) effective teaching practices, representing differing viewpoints, theories, "ways of knowing" and methods of inquiry in the teaching of subject matter concepts. Multiple teaching and learning strategies should help engage students in active learning opportunities that promote the development of critical thinking, problem solving, and performance capabilities while helping them assume responsibility for identifying and using learning resources. 3) effective assessment, incorporating formal tests; responses to quizzes; evaluation of classroom assignments, student performances and projects, and standardized achievement tests to understand what students have learned. Assessment strategies should be developed that involve learners in self-assessment activities to help them become aware of their strengths and needs and encourage them to set personal goals for learning. 4) technology skills, knowing when and how to use current educational technology, as well as the most appropriate type and level of technology to maximize student learning.

Selvi [16] defines the following professional competences:

Field competences;
Research competences;
Curriculum competences;
Lifelong Learning competences;
Social-Cultural competences;
Emotional competences;
Communication competences;
Information and Communication Technologies (ICT) competences;
Environmental competences.

At the level of the individual, Elton identifies the following dimensions of teaching excellence (in our case – teacher professional competency):

Being a reflective practitioner (putting self-reflection systematically into practice);
Being an innovator;
Designing curricula;
Providing a teaching service to the community;
Researching into the teaching of one's discipline;
Conducting pedagogic research;
Being a scholar in one's discipline" [4].

4 Main Body

The basis for teacher professional competency is a developing a teacher experience which has the following structure [12]: 1. individual knowledge, 2. skills (competences), 3. acquired skills, 4. habits. Let's look at them separately.

1. The basis for the development of individual human knowledge is, of course, social consciousness in its different forms – language, morality, science, etc., the carrier of which, is social knowledge. Social and individual knowledge differs. If social knowledge can exist separately from a person - in information carriers in the form of books, etc., then the knowledge of each individual is inextricably linked to his/her experiences, with the system of personal values.

There are 4 levels of individual knowledge development:

– the first level-knowledge is a recognition of objects, phenomena, processes, properties when re-perception of previously learned information about them or actions with them.
– the second level is knowledge-copies. It involves reproductive actions by independently reproducing and applying information about the object and actions with them.
– the third level involves productive actions to apply the information received in different situations; in the process of independent work.
– the fourth, highest level is knowledge-transformation. It involves the possibility of creative application of the knowledge and constructing their own activities based on knowledge.

2. Skills (competences) go on the second level. Skills can be described as the ability to perform actions mastered by a person, provided by a set of acquired knowledge and skills. Skills are considered as complex structural formations of a personality, including sensory, intellectual, volitional, creative, emotional qualities that ensure the achievement of the set goal of activity in changing conditions of its course. At the same time, skills are the highest human quality and the final goal of the educational process, its completion, lies in the formation of certain skills/competences. Indeed, all the structural components of a personality: knowledge, worldviews, interests, thinking, etc. are directed as if to the “inner plane” and located inside the consciousness. The only external manifestation of a man is his actions. And the ability to successfully and wisely act is a skill. “The ability to do something” in the most general sense means that a motivated is able to independently navigate the situation, learn it (and acquire the necessary new knowledge), correctly set the goal of actions in accordance with objective conditions that determine its reality; in accordance with the situation, the goal and available opportunities to determine specific means and methods, in the process of action to improve, work them out and, finally, achieve the goal. Naturally, many specific types of human activities, professional activities as well, include only a part of the listed components. Thus, a person can perform some actions he is ordered to carry out. It means that the goal, means and methods are set to that person from the outside, respectively, the cognitive, value-oriented and projective components are less noticeable. Skills/competences are formed on the basis of knowledge and skills acquired in the previous experience of the student.

Skills can be classified in the following way:

– By orientation: gaming, educational, labor, professional, etc.
– By levels of organization of activities: 1. operational – the ability to perform a separate process (in the wide sense) or operations; 2. tactical – the ability to organize and execute a full technological process (for example, teaching, accounting, construction, etc.) in a changing environment; 3. strategic – the ability to independently design and achieve major, long-term goals of one’s own activities, fluency and variation of different technologies, the ability to correlate one’s own activity with the goals of the whole team, with other organizations, with the environment.
– By the levels of acquisition [11]: 1) initial skills (understood as awareness of the purpose and the search for ways to perform a certain action, based on previously acquired experience). Here the nature of trial and error is clearly expressed; 2) partially efficient actions (understood as mastering skills while performing certain techniques or operations). They include clarification of the necessary knowledge system, formation of skills specific to these actions and further constructive actions. 3) skillful activity (seen as creative use of knowledge and skills with awareness of not only the goal, but also the motives for choosing ways and means to achieve the goal). 4) excellence (which is mastering skills at the level of labor strategy, creative development of the ability to independently determine the goal, creative use of various skills (technologies).

Recently, the so-called competence approach has become widespread in the pedagogical theory and practice. This approach is based on the concept of competences as the basis for the development of the student's ability to solve important practical tasks, and the development of the individual as a whole. It is assumed that "competence" is an independently realized ability to practice, to solve life problems, based on the student's acquired educational and life experience, his values and inclinations. In fact, competences and skills are synonyms.

At the same time, the competence approach which can be called a "smart approach" is a progressive and new phenomenon. Its recognition by scientists and the public means a transition to a new educational paradigm, from "knowledge" to "activity".

3. Acquired skills, in their turn, are automated components of a certain activity. They are formed during multiple repetitions (exercises) (i.e., they are performed without the direct participation of consciousness). Acquired skills and skills as competences are related as part and whole: acquired skills are specific (automated) components of a skill as competence. Any human activity is always carried out consciously. But individual operations that are part of it, as a result of multiple repetitions in the course of exercise. Thus, training no longer needs conscious control. If there are any difficulties in performing certain operations, the consciousness begins to control them again. Acquired skills are formed as the result of the fact that successful actions, movements, justified methods of regulation, are gradually selected and fixed.

4. A habit is an automated action that has become a need. It is formed in the process of repeated performance of an action at the stage of its development, when it no longer has any difficulties of a volitional or cognitive nature. A shift in the motive of action is associated with the formation of habits. If at first an action is prompted by a certain motive that lies outside it, then with the emergence of habit, the motive itself becomes the need to perform this habitual action.

Thus, teacher professional competency is developed through a teacher experience which includes: 1. individual knowledge, 2. skills (competences), 3. acquired skills, 4. habits.

Now the question is what individual knowledge, skills (competences) acquired skills, and habits do university teachers need to integrate into the world academic area?

To answer this question, the questionnaire was developed based on an extensive review of the literature that provided the most important skills necessary for university teacher professional competency. The authors conducted this questionnaire survey in the Samara State Technical University and Samara State University of Social Sciences and Education from 2014 till 2019. Data collection was done while distributing questionnaires to 300 teachers working at these institutions who confirmed concernment in their own personal career-long professional experience. They identified 23 variables as essential activities for teacher professional competency. The analyses revealed the following:

Group I. Ways of Thinking. 1. For creativity and innovation skills, the following is appropriate:

- to role modelling creative habits. Nothing is more important than teachers exemplifying habits, behaviours and thinking they want students to demonstrate. Teachers need to exemplify such creative traits as curiosity and development of creative skills;

- to treat mistakes as learning opportunities and encouraging learners also to take sensible risks in the classroom. Encouraging learners to take "sensible risks" in their work is important for building up their creative confidence. It is important that this takes place in a supportive environment, and that teachers and learners have discussed what boundaries are acceptable in a certain context;
- to give yourself sufficient time to complete an important project. Sometimes ideas need time to develop before becoming valuable. Delay judgement of ideas until working them out properly;
- to participate in the discussion in professional forums, where creative discussions of professionals take place (theoreticians and practitioners).

2. Critical thinking, problem solving, decision making:

- to appreciate the critical importance of questions, both their own and those asked by colleagues and students. Encouraging to ask questions can enable to look at the topic from different perspectives, to clarify a goal or plan for any investigation, to inspire yourself to find out the answer;

3. Learning to learn, metacognition:

- to educate yourself (study of scientific and professional journals, either in printed or electronic form, and scientific books, textbooks of recognized authors, proceedings of the international scientific conferences, symposia and seminars, etc. bringing the latest knowledge in the field);
- to be an active member in scientific and/or academic communities, associations, chambers, groups, etc. (work on the defined challenges or international projects on the one hand is the source of new knowledge from other colleagues, and on the other hand it forces teachers to gain thorough knowledge in the scientific field);
- to publish in the scientific journals and proceedings (preparation of each article always means thorough analysis of the existing knowledge in the topic concerned and own research which renews and enriches existing knowledge of the teacher); - to participate in the programs of professional development organized by firms and companies (training performed by the designers/producers of new equipment enables safe use of simulators and training under the supervision of practitioners);

Group II. Ways of Working. 4. Communication:

- to participate in foreign academic and other internships and scholarships (international environment and foreign universities can strongly accelerate the training progress at university);
- to participate in scientific conferences (scientific discussions at conferences increase knowledge and enable to obtain experience of other professionals and teachers, confront one's own knowledge and research results with results of others);
- to replace strict criticism of students and colleagues by providing supportive and motivational feedback;
- to learn when it is appropriate to listen and when to speak.

5. Collaboration (teamwork):

- to work in interdisciplinary projects (teaching of specialized project subjects requires perfect preparation by teachers at a deeper level than the teaching of classical subjects, which forces teachers to keep in permanent touch with the latest knowledge), etc.
- to receive feedback from the colleagues at the department (survey of one's own teaching through the eyes of younger and older colleagues); - to coach, mentor, consult experienced educational authorities (i.e. in advance planned and approved training in partnership with the recognized authority at the department, faculty or other institutions);
- to conduct collaborative research with different universities.

Group III. Tools for Working. 6. Information literacy:

- to learn where to start looking for information and to develop awareness of a broad range of information sources (e.g., electronic and print periodicals, chapters in books, government documents, archival material, and microfilm), and to distinguish among the various types of resources (e.g., scholarly work, informed opinions of practitioners, and trade literature);
- to select key points from retrieved information and summarize them, rather than simply repeat material from research;
- to use high-quality content and reflect evaluative thinking in the context of students' academic level and discipline, as evidenced during classroom discussions, when writing papers, creating displays, or when speaking or performing publicly; - to develop new insights or theories, or discover previously unknown facts, based on material teachers already knew;

7. ICT literacy:

- to apply technology effectively: use technology as a tool to research, organize, evaluate information;
- to use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in the modern digital world;
- to create interactive e-course books and online courses for students;
- to work with MOOCs, shared online courses, etc.

Group IV. Living in the World. 8. Citizenship – local and global; 9. Life and career; 10. Personal and social responsibility – including cultural awareness and competence:

In this research the authors pointed out that the majority of technical and vocational teachers who work in technical universities at the moment were trained at university-level institutions, but their curriculum was practice-oriented and did not include either special education subjects or subjects preparing them to successfully collaborate within international community [9].

For such teachers the authors developed the IDUTE programme (International Dimension of University Technical Teacher Education) designed to enhance the international dimensions of various components of University teacher education programmes, to transform courses in order to facilitate change and improvement in reaching the internationalization goals of their work and to help provide University teachers with greater global knowledge and competences.

The IDUTE programme modules were designed after deep studying of technical and vocational teachers' needs. It promotes internalization among them and also expands international activities which help form internationally competent teachers. The IDUTE programme includes: Module 1. Summer Schools (16 h); Module 2. CLIL Methodology in a Technical Classroom (72 h); Module 3. Making Successful Applications for International Grants (72 h); Module 4. International Conferences and Networking: Participating & Organizing (16 h); Module 5. How to Write an Article in an International Journal (36 h); Module 6. Buddy Programmes & International Field Trips (16 h); Module 7. Digitalization of Education: Online Courses for Foreign Students (72 h); Module 8. Developing Double-Degree Programmes (16 h). The programme came into force in the autumn term of 2017 as separate 16/36/72-h modules which were offered for SSTU technical teachers and is still been developed. The teachers are supposed to choose 2–4 modules a year thus covering the whole programme within the period of 2–3 years [10].

The IDUTE programme helped university teachers to get experience in the field of integrating Russian Universities into world academic area and to get knowledge and develop ten most actual skills which we mentioned previously. It became possible because the teachers who took part in the IDUTE programme worked with real people and carried out real tasks. Sure, training, instructions and literature can be helpful, but nothing beats hands-on practice and learning by doing. Only learning by doing can help to achieve the fourth, highest level of knowledge-transformation and of acquired skills as they formed during multiple repetitions (exercises). And the main principle of the IDUTE programme was the principle of convergence on the dialogue level. The programme developers did their best to organize their colleagues' active learning in such a way that their collaborative work made it possible for everyone to achieve a higher level of his/her professional excellence (competency) because during this programme they were constantly discussing different ways of developing competencies and shared their unique experience.

5 Conclusion

To develop teacher professional competency thought a teacher experience we tried to organize teacher activities in different formats. These activities include intensive themed sessions with invitation of speakers and expert lectures; role-playing scenarios; small-group tasks and discussion using video or micro-teaching fragments, case studies, practice and critical incident analysis and searching for solutions; reflection on one's professional goals and aspirations, implementation of theory-to-practice projects, e.g. development of a new educational program, exploration of writings pertinent to education, or experimenting with new teaching methods; outgoing mobility: participation of university teachers in a teaching process at foreign universities; participation in video conference meetings, development and fulfillment of distance learning courses, participation in international conferences, international research projects, joint studies, preparation of joint publications, participation in international educational projects, creation of joint international educational programmes, available international content in a scope of subjects, lecturing in foreign languages and etc.

Here we would like to highlight the fact that to develop really internationally competent technical and vocational teachers we, as this course designers, have to remember that our learners are adults with rich previous background and experience. They are busy and stressed-out researchers who hate wasting time. They want new learning experiences that help them meet their needs and achieve their goals. When creating any type of courses, it is important to base the design on a good understanding of adult learning. Adults need to know "why" they should learn. Adults are driven by internal motives. They will learn if they want to learn. For adults, the willingness or readiness to learn comes from perceiving the relevance of the knowledge. They want to know how learning will help them better their lives, and they learn best when they know that the knowledge has immediate value for them. Adults bring with them rich reserves of experiences that form the foundation of their learning. They analyze, rationalize, synthesize, and develop new ideas or tweak old ones through the filter of their experiences. As an instructional designer, you should tap into their experiences to help them make connections, perceive relevance, and derive inspiration. Adults are self-directed individuals who want to take charge of the learning journey. They are independent beings who want to feel in control Adults learn best when they "do". They find relevance in task-oriented learning, which they can align with their workplace realities. Besides, task-oriented learning exercises their problem-solving ability that in turn, gives them the confidence that they can conquer their challenges with their newly acquired knowledge. In this case teachers can rich the fourth, highest level of knowledge-transformation which involves the possibility of creative application of the knowledge and constructing their own activities based on knowledge and skill excellence which is mastering skills at the level of labor strategy, creative development of the ability to independently determine the goal, creative use of various skills (technologies).

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Motivating Students to Acquire Digital Skills

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Abstract. The rapid development of technological innovation means that companies need to transform themselves into digital enterprises. The digital transformation requires more than the introduction and implementation of digital technologies, and it has effects on all areas of an enterprise. Companies have to think of new business models, rethinking their operational models, and have to attract smart talents who can deal with this digital transformation.

Consequently, digital talents should have a broad knowledge in different domains like technology or business. This comprehensive education usually needs a couple of years, but enterprises cannot wait for years. Since there is a considerable number of business schools and universities all over the world, it could be a way to motive business students to acquire highly demanded digital skills. In addition to their business education, students can be further educated in new technologies and related skills.

The central aim of this study is to identify if a short introduction to new technologies and the related skills motivates students to acquire further knowledge of these technologies and skills, which are required for the workforce of tomorrow. An experiment with 100 participants has been conducted to collect empirical data. Hypotheses have been derived from literature and statistically analyzed. The results show that this approach seems to be a successful way to arouse interest for further education in highly demanded topics, which are required to implement the digital transformation.

Keywords: Digital transformation education · Digital skills · Digital talents · Empirical survey · Self-service business intelligence

1 Introduction

The digital transformation leads to a restructuring of entire industries, institutions, and broad areas of private life. Based on technological developments, digitalization has led to a phenomenon that has an impact on large parts of society [1, 2]. These effects also lead to structural changes in the organization, processes, and employee skills, which are needed to implement the digital transformation to reach higher levels of integration [3, 4].

"The integration of the analog and digital worlds with new technologies that enhance customer interactions, data availability, and business processes" [5].

New processes or products can be developed based on new technologies as well as through the innovative combination of several applications. These new technologies

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include cloud computing, the Internet of Things (IoT), big data and analytics [6]. Digitalization has its roots in the manufacturing domain, but the service industry applies these concepts and technologies as well. The advancements in the service domain are mainly combinations between digital services and new technologies, like Artificial Intelligence or IoT [7, 8]. If new technologies are used jointly, combinatorial effects are created that cannot be achieved if these technologies are used in isolation. The combination and of these new technologies can thus exponentially accelerate new developments (Martin et al. 2018). Those products or systems are often referred to as smart systems or products, which are closely related to the IoT [9].

Smart products and systems offer new opportunities and foster the design and delivery of a new kind of services, “that is built on obtaining contextual data from the field, analyzing these data, automatically making decisions and taking action” [10]. They are based on monitoring, optimization, remote control, and autonomous adaptation of products. An overview of smart products and systems, along with their specific characteristics, can be found in [11–13].

The related literature is presented in Sect. 2 of this paper, which lays the foundation for the empirical part given in Sect. 3. Section 4 explains the used methodology and the design of the empirical survey. The results are depicted in Sect. 5. This paper ends with a conclusion, its limitations, and an outlook for further re-search in Sect. 6.

2 Literature Review

In the following subsections, the theoretical basis for the empirical survey is presented. The first section justifies this research, followed by related work and a description of self-service business intelligence (SSBI) tools.

2.1 Need for a Skilled Workforce

Hess et al. (2016) who state that “changes in products, services, and business processes to digitally transform an organization (…) will likely require new skills” [3]. Kagermann et al. (2015) can find the same conclusion as they argue, that “… successful new business models will only emerge where complex smart products and smart services are combined and orchestrated by well-trained employees, or smart talents.” [8].

A report from the World Economic Forum gives an overview of the required skills and estimation of unfilled jobs, which are needed to drive the digital transformation [14]. Data management, Artificial Intelligence, green economy, engineering, and cloud computing are the professional clusters with expected annual growth rates of 41%, 35%, and 34%, respectively. The skills in these clusters with the highest demand cover both technical and cross-functional skills. Furthermore, each cluster requires distinctive skill sets, which are cluster-specific.

While some professional clusters, such as data management, artificial intelligence, engineering, and cloud computing, require substantial expertise in digital technologies, other high-growth professions place greater emphasis on business skills or specialized industry skills. Further detailed discussions on skills, which are required for the digital transformation can be found in [15–18]. Research on skills has revealed that a wide variety from different disciplines is needed, especially the combination of technical and business skills.

In this context, the education of topics, which are part of the digital transformation, has to be provided by all kinds of educational institutions. Based on the required skills, universities have to offer a broad range of topics, integrating business and technical contents. This should digital transformation professionals enable to solve problems quite agile and a comprehensive understanding of interrelated fields [19].

2.2 Self-service Business Intelligence

With the fast development of web technology, more and more companies have been seeking for a method of facilitating their business decision-making process. Technical advancements had a strong influence on the development of BI tools. First, Big Data generates a large volume of data, coupled with a vast variety, which is different from classical data management [20].

Secondly, the emergence of cloud computing changed the way companies use the software. Companies are able to lease these services on-demand, without being obliged to buy hardware, software, or recruit a technical management team, and simply use the entire system via the Internet [21].

Thirdly, while initially, BI was only responsible for strategic questions, its scope has further been extended to operational tasks, implying that a greater number of employees are required to apply BI by themselves on a daily basis [22]. Based on that, Imhoff and White (2011) propose the following definition: "Self-Service Business Intelligence is defined as the facilities within the BI environment that enables BI users to become more self-reliant and less dependent on the IT organization" [23].

Reddy et al. (2019) give an overview of multiple vendors and products in the SSBI domain [24]. For this research, Qlik sense cloud (https://www.qlikcloud.com/) was selected for the experiment. Qlik sense cloud is less of a traditional dashboarding tool, but more of a visual analytics and data exploration application builder. Therefore, a lot of indicators and functionalities are provided to support the analysis of data sets or tools to slice and dice the data.

3 Problem Statement and Research Overview

Since there is a considerable number of business schools and universities all over the world, it could be a way to motivate business students to acquire highly demanded digital skills. In addition to their business education, students can be further educated in new technologies and related skills.

Upon graduation, university students usually apply to companies. Thus skilled employees can contribute to the implementation of the digital transformation very quickly. The time between their education and work in the field is very short.

The research question of this study is to find out if a short introduction and usage of new technologies along with the application of digital skills arouses interest and curiosity in these technologies and skills. To make such a short introduction of new technologies very appealing and exciting to the students some hands-on activities with state of the art tools should be carried out. These topics should cover some of the new technologies and skills required for the digital transformation.

The topic of business intelligence and business analytics (BI/BA) has been identified as a suitable topic. A cloud-based self-service BI (SSBI) tool was selected to support this short introduction in BI/BA topics, because:

- Making business-related decisions is very close to the education of business students
- SSBI tools are available in the cloud for free; just a quick registration is needed
- SSBI tools are easy to use, they have a low inhibition level, which is a prerequisite for beginners
- Data from different sources (e.g. sensor data) can be used, which relates to big data or IoT
- SSBI tools provide functionalities for data-driven decision making.

4 Methodology and Design of Empirical Research

This section describes the methodological approach to collect empirical data, which can be used to answer the research question. First, the hypotheses, which are based on the literature review, are presented. Second, the design of the experiment is described and third, the selection criteria for the participants are depicted.

4.1 Hypotheses

If SSBI tools are easy to use, there should be no difference in being able to use the tool between Group A and B. The usability of a tool should not influence the potential interest in new technologies. This leads to the following hypothesis:

– H1: Participants of both groups are generally able to handle the essential functions of the cloud-based SSBI tool accurately.

To find out, if a basic knowledge in a field arouses interest for further education in this and related topics, the following hypotheses can be established:

– H2: Participants of both groups are interested in further education in cloud-based SSBI-tools
– H3: Both groups want to have more lectures on data-driven decision-making
– Related topics:
– H4: Participants of both groups are interested in further education in Big Data.
– H5: Participants of both groups are interested in further education in cloud computing.
– H6: Participants of both groups are interested in further education in smart systems and products.
– H7: Participants of both groups are interested in further education in the Internet of Things.

4.2 The Setting of the Experiment

All of the participants had to go through the following steps:

1. Answer part one of the questionnaire (general questions on the participant, usage and experiences with SSBI tools so far)
2. Carry out several tasks with a cloud base SSBI tool
3. Answer part two of the questionnaire

All items had to be rated on a Likert scale from 1 to 7. Finally, all collected data were analyzed with the statistical software platform SPSS.

4.3 Selection of the Participants

Since this is a preliminary study to explore the proposed approach, the knowledge and background participants should be on a comparable level. This requires a quota sampling approach, which is a sampling method that gathers data from homogenous groups. Thus, the participants came from two universities. This ensures that the participants have a rather homogenous and comparable background in their business education.

Two user groups have to be defined, Group A, which consists of students who have already used BI/BA tools in their education and Group B, which has not yet used such a tool. Students in Group A had to successfully (grades <1.5) participate in at least three courses in business informatics or BI. Students associated with Group B were not allowed to have already joined those courses.

5 Results

This section presents the results of the empirical survey. First, a description of the participants is given, followed by the validation of the hypotheses.

5.1 Descriptive Statistics of the Participants

A total of 100 experiments have been conducted and subsequently evaluated. Group A has 13 and group B 87 participants. This different number of participants was intentionally selected to get more information from students that have not yet used cloud-based SSBI tools.

The average age of the participants is 23 years, with the youngest being 19 and the oldest being 29 years old. The distribution of gender shows that 60% of the participants are male (n = 60), and 40% female (n = 40). The shortest experiment was conducted within 12 min, and the longest took 22 min. The average duration was approximately 15 min.

5.2 Validation of the Hypotheses

First, the distribution of the data has to be examined to use the correct statistical analysis method. A Shapiro-Wilk test revealed that all items are not normally distributed ($p < 0.05$). Consequently, a non-parametric test has to be used [25].

The Mann-Whitney U-test, also called Wilcoxon-Mann-Whitney test, can be used to compare the ranked means of two independent samples. The null hypothesis of the Mann-Whitney U-test states that there is no significant difference between groups. The following settings were used: a) significance level $p < 0.05$ and b) asymptotic significances.

H1: Participants of both groups are generally able to handle the essential functions of the cloud-based SSBI tool accurately (Table 1).

Table 1. Means for hypothesis 1.

		N	Mean	Standard deviation	Standard error of the mean
Tool handling	Group A	13	39,5385	2,29548	,63665
	Group B	87	38,5977	2,85078	,30564

Since the dimension tool handling consist of 6 individual items, the maximum value equals 42 (6 items multiplied by 7-step Likert scale). The arithmetic means of both groups (Group A = 39.54; Group B = 38.60) indicate that the tool is rather easy to use and does not require previous knowledge to be used properly (Table 2).

Table 2. Test Summary for hypothesis 1.

	Significance	Decision
Tool handling	,236	Retain the null hypothesis

This result shows that there is no significant difference concerning the usability of the tool.

These results are consistent with the previously analyzed studies which state that SSBI tools should be intuitively and easy to use, independent of the user's background and knowledge in math and statistics [22, 26–28].

The assumption that a piece of basic knowledge arouses interest for further education in this filed and related topics have to be verified. Thus, the following hypotheses have to be tested:

Table 3. Summary of the means of the variables for hypotheses H2-H7.

		N	Mean	Standard deviation	Standard error of the mean
H2: I am interested in attending courses using cloud-based SSBI-tools	Group A	13	6,54	,660	,183
	Group B	87	6,09	1,197	,128
H3: I am interested in having more lectures about data-driven decision making	Group A	13	6,46	,519	,144
	Group B	87	5,89	,882	,095
H4: I am interested in having lectures about Big Data	Group A	13	6,23	,725	,201
	Group B	87	5,84	1,066	,114
H5: I am interested in attending courses about cloud-computing	Group A	13	5,92	,862	,239
	Group B	87	5,56	1,064	,114
H6: I am interested in having lectures about smart systems and products	Group A	13	5,23	,927	,257
	Group B	87	5,31	1,174	,126
H7: I am interested in having lectures about the Internet of Things	Group A	13	5,77	,927	,257
	Group B	87	5,69	1,082	,116

For all items, the maximum value is 7. All means of all items are above 70% of the maximum value. This can be interpreted as strong demand for further education in BI/BA and related fields. To find out, if there are differences between Group A and Group B the hypotheses have to be tested. The following table shows the summary of the test results and the decision about the hypotheses (Table 4).

All hypotheses, except H3, have to be accepted, meaning that there is no significant difference ($p < 0.05$) between both groups. These results clearly show that both groups are interested in further education in BI/BA and related fields.

Only H3 (lectures about data-driven decision-making), has to be rejected. The arithmetic means (Group A = 6.23; Group B = 5.84), as depicted in Table 3, already indicate that there is a difference between the groups. Further investigations are required to find reasons for that difference.

Table 4. Test summary for hypotheses H2-H7.

	Significance	Decision
H2: I am interested in attending courses using cloud-based SSBI-tools	,247	Retain the null hypothesis
H3: I am interested in having more lectures about data-driven decision making	,020	Reject the null hypothesis
H4: I am interested in having lectures about Big Data	,250	Retain the null hypothesis
H5: I am interested in attending courses about cloud-computing	,237	Retain the null hypothesis
H6: I am interested in having lectures about smart systems and products	,739	Retain the null hypothesis
H7: I am interested in having lectures about the Internet of Things	,810	Retain the null hypothesis

6 Conclusions, Limitations, and Recommendations

The results show that the approach presented in this paper may generate interest in digital technologies and skills by business students. Being educated in business and technical domains enable students to work effectively in digital transformation projects. Since students are usually applying for jobs after graduation, the time from education to practical experience can be short.

In general, the quantitative research approach was suitable to reach the central aim of this research project and answer the research question. Nevertheless, there are limitations, which reduce the generalization of the results: a) the number of the experiments, b) the participants came from two universities, c) the unbalanced number of participants in the two groups.

To get more insights, it is required to redo this experimental setting with more students from different universities, ideally from all over the world. The quantitative data, which are collected by this setting, should be extended with qualitative data. Qualitative data can be obtained, for example, with interviews or focus groups conducted with the participants.

A short introduction of different new technologies demanded by digital transformation activities can easily be integrated into already-existing courses. Besides BI/BA, other topics should be identified to provide a wide range of technologies with the related skills that should arouse interest and curiosity in these fields.

To get a comprehensive understanding, it is required to redo this experimental setting with more students from different universities, ideally from all over the world. The quantitative approach should be extended with qualitative data.

Based on the first insights into these new topics, individual training needs can be derived. Universities should consequently offer additional courses that satisfy this sincere desire for knowledge. This approach represents an easy and quick way to attract more students to get deeper into knowledge, which is demanded by organizations to implement their digital transformation initiatives. There is no need to change the curricula of existing study programs.

Literature recommends continuous professional training for the workforce to keep up with the latest developments. This approach can also be used to offer first insights into new topics.

It has to be evaluated if the approach presented in this paper is also suitable to help workers in the field to quickly identify their interests. Based on the results, personalized and workplace-related pieces of training can be used for further education. Universities can offer related post-graduate courses or modules.

Further research is needed to identify more applications and hands-on activities where this approach can be applied. The development and study of different settings to achieve the same goal can be an additional research stream.

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Application of Microfluidic Techniques to Experimental Research of Engineering Students

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Abstract. Experimental research is a key part of student projects in many engineering education areas. Modern research methods often require expensive equipment and a well-equipped laboratory to obtain robust and reproducible results. A good alternative for student research is microfluidics. It provides a fast and cost-effective overview of chemical engineering processes such as diffusion, convection, reactions, and phase separation.

The purpose of this work was to develop a microfluidic practicum for a Master's program in chemical engineering and test it with students.

The microfluidic technique selected for this research is measurement of diffusion coefficients of various soft matter systems, such as polymers, surfactants and quantum dots T-sensor type microfluidic chips. Such a technique is a valuable tool for students pursuing degrees in nanotechnology, biotechnology, or polymer engineering.

Two experimental practicums were developed for engineering students based on microfluidic technology and tested successfully with students. Students obtained reproducible experimental results that are in good agreement with conventional methods. These practicums offer students an overview of chemical synthesis, convection, and diffusion. To evaluate diffusive characteristics of soft matter, students work with a simple tool that is cheaper than bulk methods such as dynamic light scattering. A motivating factor for research is that microfluidic tools can be designed and fabricated by students themselves.

Keywords: Experimental research · Microfluidics · Graduate education · Soft Matter · Master's program

1 Introduction

Experimental research is an indispensable component of student projects in almost all areas of engineering education. Modern research methods often require expensive devices and a well-equipped laboratory to obtain robust and reproducible results. A good alternative for student research is microfluidics. It provides a fast and cost-effective overview of basic chemical engineering processes such as diffusion, convection, reactions, and phase separation in such areas as chemical engineering, biotechnology, and polymer chemistry [1, 2]. Developing of new approaches to

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training of engineering students is important in a modern globalizing and rapidly developing world [3–5] especially for countries integrating into global education systems [6]. Microfluidics is a promising approach not only for research but as well for developing new experimental solutions for chemical engineering education [7, 8].

Experimental practicums offered for undergraduate and graduate students in chemical engineering often focus on basic aspects of science. The desired outputs of experiments in such practicums are often qualitative or quantitative data with less accuracy requirements as compared to PhD or postdoc research projects, which usually involve a lot of complicated and expensive techniques, for example, in polymer chemistry and engineering [9–11]. The transition from conventional high-cost macroscopic devices to more cost-efficient microfluidic alternatives offered for such students can offer a good potential to modernize experimental practices in chemical engineering education.

The purpose of this work was to find a microfluidic alternative for undergraduate and graduate student experimental research in chemical engineering and test it with students. This project is a part of an ongoing large-scale engineering education internationalization and networking initiative [12], which has been performed in Kazan National Research Technological University for the last five years train chemical engineering students with skills in innovations [13, 14], motivation for lifelong and extracurricular learning [15, 16] and ability to work in multilingual [17] and intercultural environment [18–21]. Although microfluidics seems to be far from these areas at the first sight, it offers unique opportunities for engineering students to integrate with their mates around the world because it proposes standard approaches to fabrication of microfluidic chips, teams in microfluidic laboratories are strongly internationalized, and students involved in research with microfluidics demonstrate high motivation in using their research and extracurricular time for developing interdisciplinary innovative initiatives from their university projects.

2 Approaches to Development of Microfluidic Practicums

The microfluidic technique selected for introduction to research activities of engineering student is synthesis of nanoparticles from polymers, surfactants, and quantum dots. Students also learn basic characterization of soft matter systems such as evaluations of diffusion coefficients of various soft matter systems, in T-sensor type microfluidic chips. Such synthetic and characterization techniques are valuable tools for students pursuing degrees in advanced materials, nanotechnology, biotechnology, and polymer engineering. The topics for experimental activities were selected with the focus on their possible further adaptation to other undergraduate and graduate programs. In a longer-term perspective, these experimental activities were added, in the form of practicums? To the project of a new Master's program in smart materials, which has been developed by a network of Russian universities in chemical engineering and materials science.

Two groups of chemical engineering students were selected to test microfluidic methods in their research projects: 15 Bachelor's students studying chemical engineering and 12 Master's students studying molecular materials science. Bachelor's students selected for testing the practicums study Polymer Engineering as their major. Master's students study the Molecular Materials program.

Within the framework of these experimental activities, Bachelor's students performed basic experiments characterizing mobilities of ions and diffusion of polymers. Master's students synthesized soft matter systems from polymers, surfactants and/or quantum dots and characterized sizes of nanoparticles.

The experimental activities developed for both groups are interdisciplinary and include mathematics (solving partial differential equations), chemical kinetics (reaction processes), physics (hydrodynamics, convection, and diffusion), and CAD practices (design and fabrication of microfluidic devices).

3 Results and Discussion

3.1 Microfluidic Experimental Practicum for Bachelor's Students

Two experimental practicums were developed for engineering students based on microfluidic technology and tested successfully with students. The first practicum is dedicated to fabrication of microfluidic chips using a standard soft lithography technique and synthesis of supramolecular systems from polymers and surfactants in such chips. This practicum has been developed for Bachelor's students. According to surveys performed and the obtained teaching experience, students turn out to be excited with an opportunity to produce their own microfluidic reaction system from scratch: to design microchips, fabricate them, and finally test with solutions of various reacting chemicals. Figure 1 shows examples of microfluidic chips designed and fabricated by the students and the respective microfluidic experiments they performed.

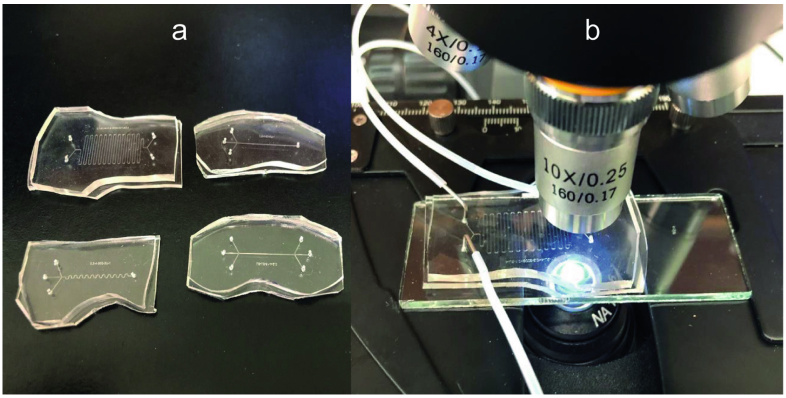

Fig. 1. Microfluidic chips fabricated by the students within the practicum (a) and microfluidic experiments (synthesis of nanoparticles by cross-linking of polymers) performed within the framework of a graduate student project (b).

Students apply a standard soft lithography technique to fabricate their chips. First, they design photomasks in the CAD software. They can print such photomasks with conventional printers for experiments that do not require high accuracy in microfluidic chip design or order high-quality print-outs of photomasks via university services. The second step is to make silicon wafer molds with photoresist and finally cure polydimethylsiloxane poured on these molds. Alternatively, students can use a broad set pf photomasks or molds provided by the laboratory.

Figure 2 shows samples of polymer-surfactant nanoparticles students synthesized in microfluidic devices as part of their undergraduate research project. Students learn how to control the properties of nanoparticles such as their size by changing operation mode of a microfluidic set-up.

3.2 Microfluidic Experimental Practicum for Master's Students

A more advanced practicum has been developed for Master's students. At this level, microfluidic experiments that students perform are based on deeper knowledge of mathematical background of processes occurring in microchips. A system of Eqs. (1) demonstrate an example of equations students learn to solve with numerical methods within the microfluidic experimental practicums. Students learn basics of Matlab and how to solve partial differential equations with Matlab Partial Differential Equations Toolbox.

$$\begin{cases} U\frac{\partial C_A}{\partial l} = D_A\frac{\partial^2 C_A}{\partial w^2} + D_A\frac{\partial^2 C_A}{\partial h^2} - k_1 C_A C_B + k_2 C_C \\ U\frac{\partial C_B}{\partial l} = D_B\frac{\partial^2 C_B}{\partial w^2} + D_A\frac{\partial^2 C_A}{\partial h^2} - k_1 C_A C_B + k_2 C_C \\ U\frac{\partial C_C}{\partial l} = D_C\frac{\partial^2 C_C}{\partial w^2} + D_A\frac{\partial^2 C_A}{\partial h^2} + k_1 C_A C_B - k_2 C_C \end{cases} \tag{1}$$

Here all the variables characterize properties of a microfluidic system, such as flowrate (U), diffusion coefficients of reaction species (D), reaction rate constants (k), and etc. Such equations are good example of non-linear equations, which characterize a broad range of real processes in chemical engineering, not limited to microfluidics. Such systems are not described in detail at the level of calculus, as they require numerical software to solve them.

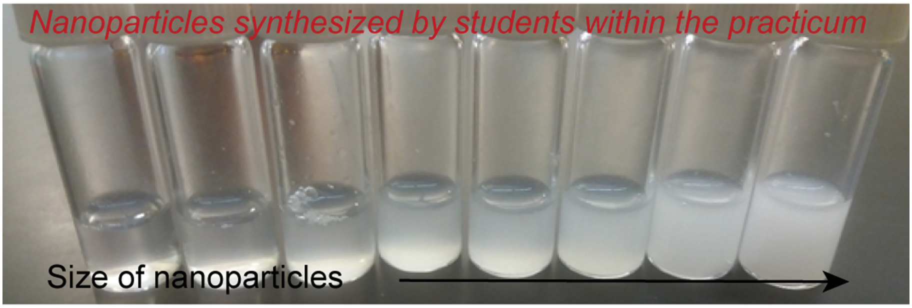

Fig. 2. Polymer-surfactant nanoparticles synthesized by a group of Bachelor's students in microchips within their practicum task. Students learn how to control the size of nanoparticles by changing operation modes of a microfluidic chip.

Solving such equations for microfluidic devices helps students to get important skills in combining mathematics with real engineering problems. Students also learn how to visualize results of numerical simulations with 2D and 3D plots. Figure 3 shows an example of numerical simulation performed by a group of Master's students to calculate concentrations of polymer-surfactant complexes alongside and across a microchannel. These plots describe a chemical reaction occurring in a microfluidic channel and help students to select optimal conditions for a chemical process they plan to perform in microfluidic confinement.

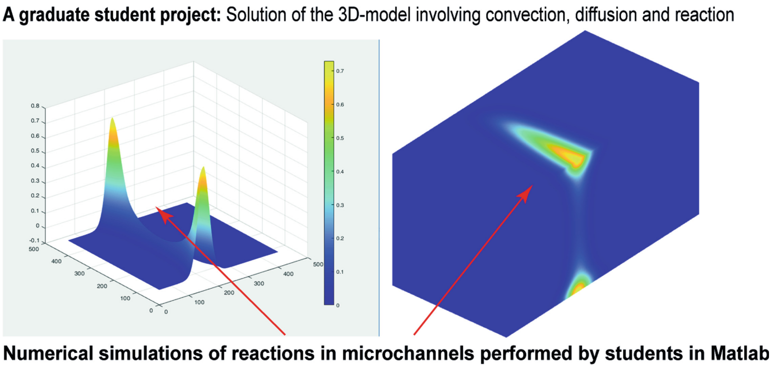

Fig. 3. Numerical simulations of a microfluidic processes performed by a group of Master's students in Matlab for evaluations of diffusion coefficients of polymer macromolecules.

Another important aspect of experiments that Master's student perform with microfluidic chips is the focus on utilizing potential of microfluidics in characterization of processes occurring inside microchannels. Comparing the results of experiments that students perform in microchips with numerical simulations results, they evaluate important characteristics of reaction species in microchannels. Figure 4 demonstrate an example of the experiment, where students evaluated diffusion coefficients of polymer particles in solution from simulation results (a) and optical microscopy data (b).

A macroscopic method that offers similar analytical capabilities is dynamic light scattering (DLS), which is much more expensive, than this microfluidic setup. Students, however, can compare their microfluidic and macroscopic analysis results, what they actually do during this experimental practicum: they measure sizes of nanoparticles both with DLS and microfluidics and get important skills in the analysis of data from different analytical techniques. On the other hand, if a laboratory at a university is not equipped with expensive macroscopic analytical equipment, students become less dependent on such analytical methods with adequate microfluidic alternatives.

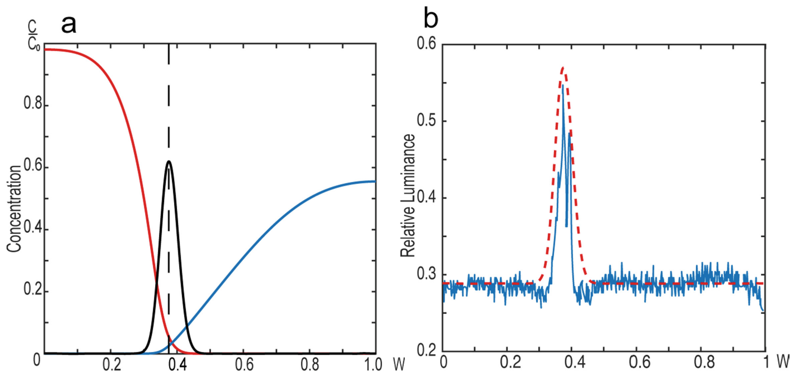

Fig. 4. An example of a Bachelor's student project: theoretical characterization of a chemical reaction in a microchannel is compared with optical microscopy image analysis data.

3.3 Survey After Testing of Practicums

A brief survey was carried out among the groups of students involved in the project after they treated these experimental practicums. The students were asked to compose a brief essay on their motivation to use microfluidics techniques for their further research projects, and advantages or disadvantages of microfluidics over analogous macroscopic approaches to experimental research.

The survey revealed to main trends in how students evaluate potential of microfluidics for their experimental research practices. The majority of students (over 80%) indicated that the basic motivation to use microfluidic devices for their research is the opportunity to design their own experiment "from scratch": to fabricate a microfluidic device, to calculate experiment parameters, and to perform experiment in a microchip. Students also indicated that microfluidic experiments are more complicated compared with traditional microscopic techniques and require additional 1–2 weeks to get proper practical skills and deal with microchips smoothly.

Students have also indicated that microfluidics is more convenient for research that is less dependent of their curriculum and can be integrated with research initiatives from other departments and institutes, because this area is strongly interdisciplinary. Students mentioned innovative potential of microfluidics and that related research has better potential for further commercialization as it is less dependent on expensive lab equipment and related requirements for research.

As a part of a larger-scale project dedicated to development of an international Master's program, these experimental practicums contribute to implementing of university's internationalization strategies in multilingual and multicultural environment. The project is based on cooperation with microfluidic research laboratories in universities from the USA Germany, and China. A mobility grant to perform research in the US partner university has already been obtained as a part of this project.

4 Conclusions

Experimental techniques developed within the framework of this project propose a method of experimental research for engineering students based on microfluidics – a technology dealing with ordered processes at a microscale. It offers students a convenient tool to study processes of chemical engineering and characterize diffusion and convection in soft matter systems.

Two experimental practicums were developed for engineering students of Bachelor's and Master's degree program level based on microfluidic technology and tested successfully with students. These practicums are focused on synthesis of supramolecular systems in microchannels and their characterization. Students obtained reproducible experimental results that are in good agreement with conventional methods. These practicums offer students a multidisciplinary overview of chemical synthesis, convection processes, and diffusion of nanoparticles in microfluidic environment.

Another important outcome is that two groups of students involved in this project demonstrated higher motivation to perform experimental research as compared to research with traditional techniques. The motivating factor for research is that microfluidic tools can be designed and fabricated by students themselves. Students obtain more freedom and creative capabilities for their undergraduate and graduate research projects as they become less dependent on high-cost and bulk research equipment. Additional time resources should be, however, considered in such practicums (1–2 weeks) so the students can obtain practical skills in proper work with microfluidic devices.

Experimental research techniques integrated with potential of microfluidics to visualize and control physical, chemical, mechanical, and hydrodynamic processes at a microscale can be adapted to a broad range of other academic programs in engineering education.

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Is Goode Still Good?

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Abstract. South Africa became a co-signatory to the Washington Accord for engineers in 1999, and later a founding co-signatory to the Sydney Accord for technologists in 2001 and the Dublin Accord for technicians in 2002, and plays a leading role in engineering education in Sub-Saharan Africa. This paper describes the evolution of engineering education in South Africa, the impact of an unprecedented educational transition caused by recent changes in national policy, which might influence mobility and the international recognition of qualifications, and an industry-informed future direction for engineering education at South African universities of technology.

Background: It was only in 1968 that the Professional Engineers Act governing the professional registration of engineers was promulgated in South Africa. The formal recognition of other members of the engineering team and associated qualifications, in particular technicians and technologists, began only after the recommendations of the Committee of Inquiry into the Training, Use and Status of Engineering Technicians in the Republic of South Africa, commonly known as the Goode Report after the chairman of the committee, R.C. J. Goode, was published in 1978. International recognition was attained only much later, when in 1999 the Engineering Council of South Africa (ECSA) became a co-signatory to the Washington Accord for engineers, and later a founding co-signatory to the Sydney and Dublin Accords. These initiatives eased the mobility of engineering practitioners and the recognition of qualifications in co-signatory countries.

Purpose: Although the adoption of the recommendations of the Goode Report created a stable environment for the training of the engineering team in the Southern African environment, in December 2012, the Minister of Higher Education and Training approved a revised Higher Education Qualifications Sub-Framework (HEQSF) published in the Government Gazette No. 36003, which is creating a disruptive influence on the qualifications offered by universities of technology, international comparability, and industry expectations. This paper investigates whether the core recommendations of the Goode Report are still relevant, valid, and worth considering during a time when Universities of Technology (UoTs) in South Africa are experiencing an unprecedented transition which may influence mobility and the international recognition of qualifications.

Method: A questionnaire, which focused on the expected competencies and attributes required from South African University of Technology (UoT) graduates, was developed. The graduate competencies and attributes were derived from those defined by the International Engineering Alliance. The questionnaire also probed stakeholder views on Work Integrated Learning (WIL), currently a

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standard component of South African university of technology qualifications. The questionnaire was distributed to 110 stakeholders, and 54% responded.

Results: Based on the analysis of the stakeholder questionnaires, it is clear that there is a niche for South African universities of technology to focus on Sydney Accord type qualifications for technologists. Although there was overwhelming support for workplace-based WIL, significant uncertainty regarding long-term industry partnerships to ensure suitable workplace placement for students, emerged.

Keywords: Accreditation · Baccalaureate institutions · International comparability · Dublin Accord · Engineering curriculum · Sydney Accord · Universities of technology · Washington Accord · Work Integrated Learning

1 Introduction

In 1967, the South African Government transformed a number of Technical Colleges into Colleges for Advanced Technical Education (CATEs) in response to the growing needs of the South African economy for higher-level technical skills [24]. A year later, Act 81 of 1968, the Professional Engineers Act, was promulgated [25]. Since CATE graduates could not register as professional engineers, many were of the opinion that this act brought considerable privileges to the professional engineer as well as a loss of standing to other members of the engineering team, and that, in future, it will cause many to seek university education instead of more practical education at CATEs. At the Sixth Conference on the Education and Training of Engineers hosted by the Federation of Societies of Professional Engineers (FSPE) in August 1973, it was subsequently resolved to approach Government to appoint a commission of inquiry to investigate and report on the education, training, and utilization of the engineering technician. This led to the formation of the Committee of Inquiry into the Training, Use, and Status of Engineering Technicians in the Republic of South Africa, who began its work in 1974 and published a final report in 1978 [22]. This report became known as the Goode Report after the chairman of the committee, R.C.J. Goode.

One of the watershed recommendations of the committee was that the engineering team should be expanded to include Engineering Technologists (such that the complete engineering team would comprise Artisans/Operators, Engineering Technicians, Engineering Technologists (the equivalent of an Incorporated Engineer in the UK) and Professional Engineers) and that CATEs should introduce a Diploma in Technology (DipTech) to provide the training needed for this new engineering category. The commission also thoroughly endorsed a sandwich approach to training, where 50% of the training would take place in industry. In the South African engineering context, this period of placement in industry became known as Work Integrated Learning (WIL).

Another important recommendation of the committee was that Act 81 of 1968 [25] should be amended to create Registered Technician and Professional Technologist registration categories for technicians and technologists. The committee felt that the 'professional' prefix for the technologist registration category was necessary to convey the envisaged high status of the registered DipTech graduate [22].

In 1979 CATEs became Technikons [26], a term unique to South Africa more or less corresponding to Fachhochschulen in Germany and Switzerland and Hogescholen in the Netherlands, and the system was later configured so that the National Diploma (NDip) for technicians followed by the National Higher Diploma (NHDip) provided access to the Diploma in Technology (DipTech), later renamed to the Master's Diploma in Technology (MDipTech). In 1993, Technikons received permission to offer degrees (RSA, 1993) [27]. The NDip. was retained, but the NHDip and the MDipTech respectively evolved into a Bachelor of Technology (BTech) and a Master of Technology (MTech). Additional theoretical work was added to the three-year NDip, and WIL (Work Integrated Learning) in the form of placement in industry was reduced from 50% to 33.3% (1 year), allowing a BTech graduate (NDip with an additional year added) to meet the educational requirements for registration as a professional technologist (instead of the former MDipTech). Technikons were also allowed to offer Doctor of Technology (DTech) degrees. In January 2004, technikons became universities of technology [30]. The impetus for this and the envisaged role of this new type of institution were explored by a Council of Higher Education 2010 report [1] and Du Pre [12]. However, primarily as a consequence of the adoption of the recommendations in the Goode report, engineering education at Technikons, and later universities of technology, became locked into the training of technicians and technologists.

Considering the Goode report, it is clear that the committee during those early years grappled with how a technician and technologist should be defined. A technician was defined as 'the person doing work in the engineering sector at a level above that of the artisan or operator, whose standard of education is above NTC 3 level, and who also completed at least one year of suitable practical experience'. The report added that normally, 'for more than 40% of his time he should be engaged in intellectual work rather than in tasks requiring manual skills or in the supervision of such work'. The technologist was distinguished from the technician in that he can operate in a broader field, has a greater depth of knowledge, can be more intellectual in his approach, and possesses a high technical qualification' [22]. The commission conceded that given the rapid rate of technological developments, it is difficult to delineate the fields of work of the professional engineer and the technologist and that there will be occasions when their tasks and responsibilities overlap. Nonetheless, the commission made the following distinctions that were broadly aligned with the classification introduced by Mehrhof in 1976 [23]: Engineers develop new ideas and technologists mainly apply and implement ideas; The technologist is more the producer, and hence may modify processes, while the engineer is more concerned with the creation of new processes; technologists are less concerned with social, economic and aesthetic aspects of engineering work; and although some of the work done by technologists will be under the guidance of a professional engineer, they can also work independently.

Defining the roles and competencies of technicians, technologists, and engineers was not unique to the South African situation. In response to the worldwide need to improve the mobility of engineers through mutual recognition of qualifications and competence, the International Engineering Alliance (IEA) was established in 1989 with the signing of the Washington Accord to recognize substantial equivalence in the accreditation of qualifications in professional engineering, normally of four years duration [3]. This was followed by the Sydney Accord in 2001 for engineering technology qualifications [4], and the Dublin Accord in 2002 for engineering qualifications for technicians [5]. The Engineering Council of South Africa (ECSA) became a co-signatory to the Washington Accord in 1999 and was a founding co-signatory to the Sydney and Dublin Accords. The IEA also established a mutually agreed-upon framework for graduate attributes and professional competencies for engineers, technologists, and technicians [35]. Most of these graduate attributes broadly overlap with the 1976 Mehrhof classification [23], adopted by Goode et al. in 1978 [22].

In December 2012, nearly 19 years after Technikons received permission to offer degrees [27], the Minister of Higher Education and Training approved a revised Higher Education Qualifications Sub-Framework (HEQSF) [32] in terms of the 2008 National Qualifications Framework Act [31] as contemplated in the Higher Education Act of 1997 [28].

The 2008 National Qualifications Framework (NQF) Act [31] replaced the South African Qualifications Authority Act of 1995 [29]. This statute had the effect of changing NQF levels of previously registered qualifications. For most traditional universities, the newly introduced HEQSF and NQF meant ‘business as usual’. The implications for engineering faculties at universities of technology (UoTs), however, are complex. In the past, university and technikon/UoT education in South Africa were regulated by separate qualification frameworks that led to almost impermeable boundaries between institutional types, fragmentation, inequality, and inefficiency. As a result of the national merger of institutions in 2004, these boundaries started to dissolve with the creation of comprehensive universities offering both university and UoT type qualifications [30]. The HEQSF [32] and NQF [31] created a single coordinated framework that, in principle, should facilitate co-operation and articulation between institutional types.

The current UoT situation is summarized in Table 1.

Table 1. Comparison between old and new NQF levels and qualifications

SAQA Act [29]	Historical Qualifications Engineering faculties at UoTs were allowed to offer	Qualification Types Engineering faculties at UoTs may offer under the (new) HEQSF [32]	NQF Act [31]
8	Doctor of Technology	Doctoral Degree (PhD/DEng)	10
	Master of Technology	Master of Engineering	9
7	Bachelor of Technology	Bachelor of Engineering Technology (Honours) [20]	8
		Bachelor of Engineering [13]	
6	National Diploma	Bachelor of Engineering Technology [19]	7
		Advanced Diploma [18]	
5	National Certificate	Advanced Certificate [16] Diploma [15, 17]	6
		Higher Certificate [14]	5

In terms of the SAQA Act of 1995 [29], both National Diplomas at UoTs and First Degrees (3-year degrees) at traditional universities are on Level 6. Bachelor of Technology degrees at UoTs, similar to honours degrees and professional degrees at traditional universities, is on Level 7, and masters degrees on Level 8. The NQF Act of 2008 [31] and the HEQSF of 2012 [32] unfortunately introduced more levels, with the result that HEQSF aligned diplomas are now pegged one level lower (Level 6) than first degrees which are still pegged at Level 7. The revised level descriptors associated with the HEQSF amplifies differences in depth and scope between the levels [33].

The Engineering Council of South Africa (ECSA) responded to the HEQSF by developing HEQSF compliant qualification standards. In terms of the new standards for technicians and technologists, in response to the HEQSF, ECSA developed several Level 6 qualifications (Advanced Certificate [16] and the Diploma [15] 17) in order to meet the educational requirements for registration as a technician, and Level 7 qualifications (Advanced Diploma [18] and Bachelor of Engineering Technology [19]) to meet the educational requirements for registration as a technologist.

Although the HEQSF, in theory, opens the door for UoTs to offer four-year professional Bachelor of Engineering degrees [13] and similar to traditional universities, to also train professional engineers in selected areas, it is obvious that UoTs do not possess the manpower and other resources to offer certificates, higher certificates, diplomas, advanced diplomas, first degrees, honours degrees, and professional degrees. The differentiation between institutional types called for in the 1999 National Plan for Education [9] to satisfy the diverse needs of the labour market remains valid. For the engineering industry to function properly, an engineering team comprising artisans, technicians, technologists, and engineers, is required. In 1978, the report of the committee chaired by Goode et al. [22] led to UoTs (and comprehensive universities) training technologists and technicians. This paper explores whether this paradigm created by the Goode report is still valid.

2 Purpose

The purpose of this study is twofold:

To determine what the South African industry expects from a typical UoT in terms of the HEQSF roll-out, and the extent to which these expectations are still aligned with the recommendations of the Goode report.

To determine the role of Work Integrated Learning (WIL) in HEQSF aligned engineering qualifications and the extent to which these expectations are aligned with the WIL recommendations in the Goode report.

3 Method

Each department in an engineering faculty at a South African UoT usually has a discipline-specific advisory committee comprising key members of the industry which the department serves. A questionnaire was compiled, which was primarily distributed to advisory committee members and other individuals from the industry with whom departments have links.

Based on preliminary discussions with the industry, it became clear that members from the industry hold vastly different opinions regarding graduate attributes and professional competencies for engineers, technologists, and technicians, not necessarily aligned with the IEM guidelines adopted by the Engineering Council of South Africa (ECSA). It also became clear that the answers obtained by just asking whether TUT should primarily train engineers, technologists, and technicians, were not an accurate reflection of the expected competencies and graduate attributes. Therefore, a more fundamental approach had to be followed. Rather than focusing on designations (technician, technologist, or engineer), a questionnaire, which focused on expected competencies and attributes of engineering training at a UoT, was developed. When the questionnaire was piloted, it was found that using all 13 Graduate Attribute dimensions as defined by the IEA [6], took too much time to answer, which frustrated the participants. The final questionnaire focused on only the six most salient dimensions that distinguish between technicians, technologists, and engineers.

The final online questionnaire was distributed to 110 advisory committee members and other key industry stakeholders. Only 59 persons (i.e. 54%) responded. The Cronbach alpha coefficient for Part A of the questionnaire, based on six standardized items, is 0.7, indicating that the results are fairly reliable.

4 Limitations

The questionnaire was distributed to the Tshwane University of Technology (TUT) Faculty of Engineering and the Built Environment advisory board members and other stakeholders. Since TUT is situated in the Gauteng province, the industrial heartland of South Africa, the results should be relatively representative of the industry, but there may be differences between the provinces, industries, and communities that the UoTs serve.

5 Findings

The findings are summarized in Tables 2 and 3.

Table 2. Part A of Questionnaire (Graduate Profile)

The main focus of an engineering education at a UoT should be to teach students to solve problems that have the following characteristics:	
Concrete problems with few conflicting constraints, which can be solved using standard codes and procedures	35%
Unfamiliar problems with a large degree of uncertainty and many conflicting constraints with no obvious solution	18%
Problems with some uncertainty and conflicting constraints where the solution partially falls outside standard codes and procedures	**47%**
The main focus of an engineering education at a UoT should be to teach students to engage in a range of engineering activities which:	
Involve diverse resources, interact significantly, and extend beyond the use of existing materials and techniques	38%
Involve limited resources, have limited interaction, and require standard materials and techniques	5%
Involve a variety of resources, might interact and often require the use of new materials and techniques in novel ways	**57%**
The primary focus of an engineering education at a UoT should be:	
In-depth theoretical knowledge and analytical skills and to comprehend and apply advanced knowledge of widely applied principles	36%
Sound knowledge of principles and knowledge embodied in widely accepted procedures, processes, systems or methodologies	**51%**
Limited theoretical knowledge and extensive practical knowledge embodied in standardised practices and procedures	13%
The primary focus of an engineering education at a UoT should be to teach students to:	
Use sophisticated strategies and tools to design and oversee potentially very complex systems, components and processes	37%
Execute intermediate design functions and contribute to the design of systems, components or processes	**52%**
Use design recipes to execute simple design functions	11%
The primary focus of an engineering education at a UoT should be to teach students to conduct technical investigations involving:	
The design of experiments and the execution of standard or routine tests and measurements to arrive at conclusions	32%
Execute standard or routine tests and measurements to arrive at conclusions using standard codes and procedures	23%
The design of experiments and the analysis and synthesis of complex information to arrive at conclusions	**45%**
The primary focus of an engineering education at a UoT should be to teach students to:	
Use modern engineering tools to solve engineering problems	23%
Select and use modern engineering tools, including those involving some modelling and prediction, to solve engineering problems	36%
Create, select and use modern engineering tools, including those involving modelling and prediction, to solve engineering problems	**41%**

Table 3. Part B of Questionnaire (Work Integrated Learning)

Questions related to workplace-based Work Integrated Learning:	Yes	No	Uncertain
Should the syllabus include a workplace-based Work Integrated Learning component?	90%	4%	6%
Is your company or division willing to enter into a long term partnership with TUT to ensure that a suitable workplace-based Work Integrated Learning placement can be guaranteed to every engineering student we enrol?	40%	0%	60%
If workplace-based Work Integrated Learning is included in the syllabus, should the period exceed 6 months (one semester)?	31%	53%	16%
Can Work Integrated Learning take the form of a meaningful industry-based final year engineering design project	82%	8%	10%

Table 4. Aggregate UoT engineering graduate profile

The profile of a UoT engineering graduate should be primarily that of a:	
Technician	19%
Technologist	**46%**
Engineer	35%

6 Discussion of Results

The aggregated results for Part A of the questionnaire are presented in Table 4, indicating that the industry prefers the profile of a technologist for UoT graduates.

Based on the aggregated results, it is obvious that the main focus of engineering education at an institution such as TUT should still be the training of competent technologists. The support for technician training is lower than that which was anticipated, especially since UoTs presently offer a 3 + 1 system where students who wish to obtain the BTech qualification (Sydney Accord accredited for technologists) have to first complete the NDip (Dublin Accord accredited for technicians). This might reflect the apparent preference among academics that industry in many cases expects NDip students to function at the Technologist level. Since the entry requirements for degrees are higher than those for diplomas, and because enrolling for a degree is in general more attractive for high school leavers, choosing the BEngTech route might allow UoTs to attract better quality students.

The results in Table 3 show that there is overwhelming support for workplace-based Work Integrated Learning (90%), but that there is significant uncertainty regarding long-term industry partnerships to ensure suitable workplace placement for all students. The HEQSF of 2012 [32] explicitly shifted the responsibility to find work placement at the university if included in the syllabus. Although UoTs, until the present, have administered and quality assured workplace placements and assisted students in finding placements, the onus ultimately rested on the student to search for and apply for available opportunities. The reluctance of companies to take on long-term obligations in an uncertain economy is currently further complicating the situation. Table 3 shows that shortening WIL to one semester and reconfiguring it to take the form of a final year project, which could also be executed on campus if a placement cannot be found, maybe a viable alternative.

7 Conclusion

The Goode report resulted in at least four watershed changes to technical training in South Africa, namely:

The expansion of the engineering team to include Engineering Technologists (such that the complete engineering team comprises Artisans/Operators, Engineering Technicians, Engineering Technologists and Professional Engineers).
The introduction of a formal qualification for technologists, namely the Diploma in Technology (DipTech) to provide the training needed for this new engineering category.
The amendment of Act 81 of 1968 [25] to create the Registered Technician and Professional Technologist registration categories.
The endorsement of a sandwich approach to training, where 50% of the training took place in industry, in the form of Work Integrated Learning (WIL), resulting in workplace-based learning that became a hallmark of CATE, Technikon and eventually UoT engineering training.

Based on the results of the stakeholder questionnaires, it is clear that industry has a need, and expects UoTs, to train technologists. Although the qualification for technologists has undergone several permutations and name changes (DipTech, MDipTech, BTech, and now BEngTech and Advanced Diploma), the Goode report created a unique niche for UoTs. Similar to Fachhochschule and Hogescholen (Universities of Applied Science) in Germany and the Netherlands, as well as other institutional types in the Sydney Accord co-signatory countries that train technologists, the Goode report enabled a similar niche in the South African educational landscape.

Under the current system, students who want to become technologists all follow a linear 3 + 1 route. They complete a three-year NDip (for technicians), followed by a one-year top-up to obtain the four year BTech (for technologists). Although the new HEQSF and the associated standards developed by ECSA still allows for a 3 + 1 route, that is, for someone to obtain a diploma that meets the educational requirements for technicians followed by an advanced diploma that meets the educational requirements for technologists, a new option to offer three-year professional degrees has also opened, that is, the BEngTech [19], which also meets the educational requirements for technologists.

The University of Johannesburg and the Durban University of Technology started to roll out HEQSF aligned BEngTech qualifications in 2017, with other Universities of Technology and comprehensive universities, including TUT, following suit in 2018 and 2019. Since the entry requirements for degrees are higher than those for diplomas, and since enrolling for a degree is in general more attractive for a Grade 12 school leaver, choosing the BEngTech route might allow UoTs to attract better quality students. However, many UoTs do not possess the resources to run the BEngTech as well as the Diploma in parallel. Although some feel that the HEQSF aligned BEngTech will lead to fewer registered technicians, the long term effect of this constraint on the training of technicians is not clear and requires further study. The question of whether technician training in South Africa should gradually migrate to Technical Vocational Education and Training (TVET) colleges also requires further investigation.

Although it is clear that the recommendations in the Goode report regarding technologists are still relevant, the sandwich approach to training proposed in the report, where 50% of the training takes place in the industry in the form of Work Integrated Learning (WIL), is under threat. After 1994, industry placement was reduced to 33% of the NDip syllabus. A survey done by the South African Technology Network (SATN) involving all UoTs shows that, based on increasing difficulties to place and monitor students in industry, the number of industry placements in the majority of HEQSF aligned Diplomas at UoTs, has been reduced to less than 33% of the syllabus [34]. The lack of industry placement opportunities will inevitably facilitate alternative forms of on-campus WIL, such as work-directed theoretical learning and tailored project and problem-based learning, as described in [34].

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