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Design of the educational process of course "Programming fundamentals" in accordance with the CDIO ideology

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Abstract. The article offers the working program for course "Programming fundamentals" of "Information systems and technologies" direction. Pedagogical technologies for implementing seven modules that are contained in course are listed. There is the list of competencies to be formed in the educational process in the context of CDIO standards as well as features of the forms of using active learning methods during classes are given. The developed curriculum contains related disciplines and includes a clear plan for integrating personal and interpersonal skills as well as skills for creating products, processes and systems.

1. Introduction

Due to with the need for quality improvement of engineering education the project was created in 2000, the main goal of which is to reform higher education in the field of engineering and technology. The CDIO initiative is widely used in educational practices [1-3]. Design of the educational process in the context of CDIO involves increasing the practical training as well as including a system of problem-based and project-based training [4].

The CDIO initiative aims to develop students' ability to [5]:

1. Acquire a thorough knowledge of the technical basics.
2. Manage the creation and operation process of new products and systems.
3. Understand the importance and impact of scientific and technological progress that affect society.

The design of the educational process in the context of CDIO initiative is implemented in accordance with the Concept — Design — Implementation — Operate model. It means that after studying under CDIO programs graduates must be able to create new products, carry out design work, and then implement the results into production. As part of the initiative 12 standards were adopted in 2004 to define the distinctive criteria of CDIO programs as well as their graduates. The 12 CDIO standards cover the philosophy of the program (Standard 1), curriculum development (Standards 2, 3, and 4), implementation of project activities and workspace requirements (Standards 5 and 6), teaching and learning methods (Standards 7 and 8), professional development of teachers (Standards 9 and 10), and evaluation of learning outcomes and the program as a whole (Standards 11 and 12). [5]

This article considers the design of educational process of course "Programming fundamentals" of 09.03.02 "Information systems and technologies" direction in accordance with Federal Educational standards of higher education (plus) in the context of the next standards:

- Standard 1 – CDIO as the context for engineering education.
- Standard 5 – Experience in project implementation activities.



- Standard 7 – Integrated curriculum.
- Standard 8 – Active learning methods.

Below there will be the implementation of these standards in the studying of the course "Programming fundamentals".

2. Course description

There is some general information about the course "Programming fundamentals". The the course "Programming fundamentals" is implemented for the 09.03.02 «Information systems and technologies» direction. The course is 324 academic hours, 108 of which are practice classes.

If we determine the learning outcomes it will help to provide the necessary foundation for successful application of the acquired knowledge in the future. It is planned that during the "Programming fundamentals", students will develop competencies in accordance with the third-generation Federal Educational standards of higher education (plus), as well as CDIO Syllabus, presented in table 1.

Table 1. Planned learning outcomes.

Planned learning outcomes of CDIO Syllabus	Universal competences	General professional competences
4.3.1. Researching needs and setting goals	UC-2: Student is able to determine the range of tasks within the set goal and choose the best ways to solve them, based on current legal norms, available resources and restrictions	GPC-6: Student is able to develop algorithms and programs suitable for practical application in the field of information systems and technologies;
3.1.1. Building an effective team		
4.4.1. Design process (products /systems)		
4.5.3. Software production process		

The application of the competence approach is one of the important conceptual provisions of the modernization of education. In accordance with this provision, education should be formed "from the result", where the main orientation is aimed at achieving specific goals-vectors of education: learning ability, self-determination, self-actualization, socialization and development of individuality [6].

3. Active learning methods

Orientation of education to the competence approach means building the learning process in such a way that the student can express himself as a subject of learning. For this purpose, modern educational technologies should be actively used, one of which is the use of active learning [7,8]. M. Smolkin say that [9] active learning methods are ways to activate the educational and cognitive activity of students which encourage them to think and practice actively during the studying process, when not only the teacher is active, but also the students are active. In the course "Programming fundamentals" active learning has a practical focus. Forms of lectures and seminars of the training modules of the course "Programming fundamentals" in accordance with standard 8 of the CDIO ideology and may include:

1. Demonstration of the process of solving a particular programming problem for the entire audience by the teacher (in the form of an interactive lecture).

2. Studying of a part of the material by each member of the student group and subsequent demonstration and discussion of the material.

3. Organization of a role play with roles of interface programmer, interface designer, module designers, testers, manager, customer and project manager.

4. Team or personal competition to get the best combination of different achievements during software development.

5. Collective assessment and discussion of any process of students' work according to the roles and work situations.

6. Consolidation of educational material, for example, in the form of updating code fragments provided by the teacher.

7. Implementation of a mini-project for the simulated provision of professional services based on materials and descriptions studied and performed at previous stages.

Active learning methods involve students directly in thinking and problem-solving processes. There is less attention to the passive transmission of information and more attention to the involvement of students in the management, use, analysis as well as evaluation of ideas and the content of the discipline. Active learning is practice-oriented when students try out roles simulating professional engineering activities, such as designing, modeling, and analyzing situations.

4. Course structure

Classes or each section of the course are implemented in accordance with standard 5 which provides students with experience in conducting design and implementation activities. The result of study of each section of the "Programming fundamentals" course is the design and development of information system. Implementation of its life cycle is carried out according to the "planning – design – production – application" which corresponds to 1 standard CDIO initiative.

Table 2. Course structure.

№	Sections of the course	of Classroom hours	Learning technology	Integrated courses
1	Procedural programming	8	Lectures: a lecture with pre-planned errors;	Algorithms and data structures, Computer science, Mathematical logic
2	Object-oriented programming	18	a consultation lecture; a problem lecture;	Data Management, Information Systems Design
3	Visual programming	10	a lecture-discussion; a two-person lecture. Seminars: a situation-sample; a problem situation; a situation-illustration.	Graphic design basics

According to the standard 7 Of CDIO seminars are carried out as integrated research tasks of the project type. Their main aim is to prepare students for project activities as well as to demonstrate future professional activities. Out of a wide range of simulation training methods we prefer the case-study method in seminars. This is a very effective method of activating the educational and cognitive activity of students. At the seminars of the "Programming fundamentals" course we use:

- A problem situation is a description of a real problem situation. The task of the students is to find a solution to the situation or come to the conclusion that it is impossible.

- A situation-illustration represents the situation and explains the reasons for its occurrence, describes the procedure for solving it. The main goal is to assess the situation as a whole, analyze its solution, formulate questions, and convey your point of view.
- A situation-sample describes the application of previously made decisions, so the situation is training. It is as an illustration of a particular topic. The purpose of the students is to analyze these situations and found solutions, using the acquired theoretical knowledge.
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- The main way to convey theoretical knowledge is still a lecture. There are several types of lectures that we use:
- A problem lecture is a lecture where new knowledge is introduced through the problematic nature of a question, task, or situation. At the same time the process of students' learning, which is in cooperation and dialogue with the teacher, is similar to the research activity. The content of the problem is revealed by organizing the search for its solution or summing up and analyzing traditional and modern points of view.
- The lecture-discussion. The content of it is given through a series of questions that students should answer directly during the lecture.
- A two-person lecture is a lecture in the form of a dialogue between two teachers. In this case it is possible to present different points of view on the same topic, to demonstrate the culture of discussion. It is important to involve students in the discussion of the problem.
- A lecture with pre-planned errors - is a lecture that encourages students to monitor constantly the proposed information by searching for errors.
- A consultation lecture is a type of lecture where the main part is the lecturer's response to students' questions. At the end of the lesson you can have a discussion that summarizes the results.

The use of active learning methods allows you to increase the effectiveness of studying by increasing the students' emotional involvement and their creative activity in the classroom. Required direct communication between students and their teacher forms a collective cohesion and intensifies the learning process. Thus, active learning methods are suitable for teaching IT disciplines, since future IT- specialists should be able to work in a team under the guidance of a senior development. This situation is similar to the roles of students and teachers in the learning process.

5. Conclusion

The «Programming fundamentals» course allows first-year students to form key competences in the framework of "Information systems and technologies" direction. This course should be definitely practice-oriented. Consequently, it is important to apply the CDIO ideology which allows us not only to increase the practical orientation of studying, but also to form the necessary competences of future information systems developers.

During the adaptation process of the "Programming fundamentals" course to the CDIO concept, the course teachers selected the appropriate standards that the course should meet, the planned learning outcomes, and active working methods. It should be noted that even today the course is focused on the CDIO ideology. It demonstrates an increase in students' learning ability, their socialization and the development of individual qualities in the professional field.

For each section of the course, the teachers have formulated their own studying technology aimed at project activities and teamwork. Active learning methods used in the course classes are of great importance. They are described in detail in this paper. Integration with other courses, in particular with the "Introduction to engineering" course, which is studied in parallel with the "Programming fundamentals" course plays an important role. This integration allows students to develop skills of creating an effective team. Integration with the "Foreign language" course allows students to expand their horizons in the professional field of the software development.

Thus, the application of the CDIO ideology to the "Programming fundamentals" course is justified and it will definitely increase the learning efficiency in the "Information systems and technologies" direction.

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