THE CONSTRUCTION OF COMPETENCY-BASED BUSINESS GAME OPERATIONAL MODEL

Alexandr Deryabin, Lidia Shestakova, Olga Vikentyeva

Abstract: *Professional staff competences may have a substantial impact on business efficiency and performance. Therefore many modern companies train their personnel in order to develop a set of professional competences. Hence a need in development of procedures for evaluation and development of competences arises. Consequently it leads to a need of developing new software, which implements those procedures. This article considers the conceptual approach to the design of ergatic competence development system elements. The article explains the concept of competence-based business game (CBG), defining it as man-machine system which allows to organize a flexible process of competence development. CBG includes technical and organizational components. Technical component forms sets of transactions, which mean the player to develop a certain level of competences. The organizational component is required to support player's activity during the game. Business game can be represented as a cybernetic system with feedback, which contains both the object of management and the management system. The game is implemented as control and operating machines accordingly. The implementation of technical component requires CBG to be divided into automate and operational models. In order to construct organizational model system analysis and domain ontology construction must be performed. Domain's (company's) business processes are represented in a form of oriented graph, traversing of which allows to develop elementary competences. Companies producing the same commodity may have different business processes. To construct competences that are applicable to similar organization, it is necessary for the graph to be a unification of every business process path. It is also possible to build a graph model of the educational management business process. This graph model must represent real management business processes of an enterprise and must reflect the logic of competence development during the learning process.*

Keywords: *competencies, active learning methods, business-game, business-process, control automat, operating automat, ontology*

ACM Classification Keywords: K.3 COMPUTERS AND EDUCATION: K.3.2 Computer and Information Science Education – *Information systems education*. K.4 COMPUTERS AND SOCIETY: K.4.3 *Organizational Impacts – Employment.* I.2 ARTIFICIAL INTELLIGENCE: I.2.1 Applications and Expert Systems – *Games*.

Conference topic: *Technology-Facilitated Learning in Complex Domains.*

Introduction

The effectiveness of contemporary, rich with information technologies, business is largely determined by human factor. It is people with professional competences who can make a substantial contribution to the organization's performance. The problem of determining employee's competence arises every time you need to select employees that are most suitable for a particular job. Employees that are involved in the organization's business processes and have the required competences are able to make a significant impact on the results of business processes. Each company designs the structure of competences based on the role of each competence in the structure of a business process.

Recent works in the field of HR give much consideration to the procedures of competence determination and development [Крюков, 2013] as well as to the development of software that implements these procedures.

There are projects in Europe that focus on Competence-based education (CBE). Project “TenCompetence” (http://www.tencompetence.org) combines models and tools, used for creation, storage and exchange of knowledge and recourses. Project “Learning in Process” aims to create an integrated new generation system of e-learning, which will support contextual delivery of electronic educational recourses to the user. In <> [Draganidis, 2010] much attention is payed to a system’s prototype, which is based on ontology, used as a tool of competence management. The system inegrates competence management with e-learning.

[Гирев, 2010] considers an intelligent system of interactive learning Stratum (http://www.stratum.ac.ru/), which provides knowledge and associated collection of interactive models, tasks and books. It also contains a built-in expert system, which automatically registers and evaluates the actions of students, and offers personal help.

Simulators deserve attention as well, due to their ability to develop professional competences. For instance, STS – Europe’s leading developer of software products in the field of project management education offer a computer simulator SimulTrain, which immerses participants in a real project’s environment and allows to make management decisions while being under tight time pressure.

Dynamics of modern production and the need to constantly improve its performance and effectiveness require high-performance systems of employee competence development to be built. Consequently, the implementation of such systems creates a need in new development tools.

This article considers the conceptual approach to the design of ergatic competence development system elements. The article explains the concept of competence-based business game (CBG), defining it as man-machine system which allows to organize a flexible process of competence development.

The suggested approach extends the ideas of creating a set of development tools for active learning methods in a form of competency-based business game studio, stated in [Викентьева, 2013]. Current approach determines the structure of business game studio and depicts the set-theoretical representation of the business game design process. Business game can be represented as a cybernetic system with feedback, which contains both the object of management and the management system. The game is implemented as control and operating machines accordingly.

Technical side of CBG is constituted by two components: automate model (AM) and operational model (OM). This article considers an approach to determination of operational model structure.

The Concept of Competence-Based Business Game

Competence-based business game is an information system, which aims to give a certain level of professional competence while implementing scenarios that are determined by business-process models of the domain [Vikenteva, 2013].

Following function represents the result of a business process

$$R = f(K, M, U), \tag{1}$$

where R – business process result ;

K – level of overall employee competence;

M – quality of input materials or resources;

U – quality of business process management.

The level of overall competence K represents an integral characteristic of human recourse, which determines the result of the business process. The level of overall competence is composed from the levels of elementary competences of individual recourses. Associated with elementary business process operations:

$$K = \sum_{i=1}^{N} k_i^b \times 1/s_i , \quad (2)$$

where k_i^b – level of *i*-th elementary competence in the business process *b*;

s_i – complexity factor of the *i*-th elementary operation.

Each elementary competence k^b, generally, may have *l* levels, where *l* depends on the subjective opinion of educational system developers (experts) and can take up different values. Each elementary operation can have *t* levels of complexity, which also can be determined by an expert.

Statement 1. For any elementary competence k^b that supports elementary operation μ^b, there exists a test *W*, which is represented by a tuple

$$W = < w_1, w_2, \ldots w_h > , \quad (3)$$

where w_j – *j*-th question of the test.

Statement 2. Any process (business process), performed in order to get a result in a finite number of elementary operations, can be represented by a oriented graph

$$G = < V, E > , \quad (4)$$

where *G* – business process graph;

V – set of graph nodes associated with elementary operations μ^b;

E – set of graph edges associated with elementary operations connections (relations).

Any elementary competence k^b can be constructed during graph *G* traversal. Traversal may be performed multiple times. The process of competence construction from now will be called the learning process.

While building a model of an organization's business process in order to use this model in the learning process it is necessary to [Викентьева, 2013]:

1. Perform system analysis of the domain and domain ontology construction

2. Build a model of educational business process G^u, using concepts and rules of ontology inference. The business process is to be represented by a graph with multiple paths but no cycles. The nodes of the graph are to represent elementary operations of primary and secondary business processes of an enterprise. Graph must have only one node that stands for the beginning of business process and only one node that stands for business process. Each node except the first and the last one must have a single input and a single output, i.e. the node's degree $\rho(v)$=2 and outdegree $\rho^-(v)$=1, indegree $\rho^+(v)$=1. Each path of the graph defines the steps that a player must make in order to execute business process completely. Each path is an alternative to other paths.

Companies producing the same commodity may have different business processes. To construct competences that are applicable to similar organization, it is necessary for the graph to be a unification of every possible business process path:

$$G^u = \bigcup_{i}^{n} G_i^B \quad (5)$$

where G^u – graph of the educational business process,

G_i^B – paths of the real business process graph.

3. Build a model of educational business process U^u, using concepts and rules of ontology inference. This graph must represent management business processes of an enterprise and must reflect the logic of competence development during the learning process. Such graph may contain cycles and various type of nodes (start node, condition node, operation node, final node) with various degree *ρ(v).*

By analogy with (5) the management business process is expressed in the following form:

$$U^u = \bigcup_i^n \left(U_i^B, U_i^L\right), \qquad (6)$$

where U^u – graph of the educational management business process,,

U_i^B – paths of the real management business process graph,

U_i^L – paths of the educational business process graph, which reflects the logic of competence.

A correspondence may be built between the set of graph paths of the educational business process (EBP) and the sets of competences. This correspondence may be organized in a form of traceability matrix of the EBP by the competences (competence matrix, CM).

Definition 1. A row of competence matrix determines paths in G^u and U^u, required for the construction of competence k^b The combination of these paths is to be called the CBG scenario.

Thus, CBG must consist of procedural guidelines, hardware, infoware, software, a scenario and tests to check the level of competence development [Викентьева, 2013].

Automate and Operational Models

Competence-based business games are supposed to be designed, developed and implemented within a specific environment, referred to as Competence-based Business Game Studio (CBGS) [Викентьева, 2013].

CBG is an ergatic (man-machine) information system:

$$G =< \psi, T >, \qquad (7)$$

where Ψ – elements related to human activity (teaching materials);

T – elements related to information system (hardware, software, infoware, scenario etc..).

Thus, from items (4), (5), (6) and defeinition 1 a conclusion may be drawn that competence k^b may be successfully developed only if CBG (7) adequately expresses domain concepts.

Domain must be described as an ontology on the CBG development stage.

Domain ontology may be represented as [Ганюкова, 2007].

$$O =< Q, S, I >, \qquad (8)$$

where Q – set of domain terms;

S – semantically meaningful relationships;

I – definitions of interpretation functions.

An ontology is a set of domain concepts, used by developers (experts) to create models of educational business processes and relations between them. Ontology permits to use the same concepts repeatedly to define different business processes of different enterprises. Moreover, it is possible to integrate several ontologies, hence describing parts of bigger domain. The use of ontologies also allows to separate domain knowledge from operational knowledge. To illustrate this let us say there is an algorithm, which describes the implementation of business process for the production of commodity *A.* The same algorithm may be then used for the production of commodity *B*, provided the latter commodities' ontology is given.

Ontology development suggests [Noy, 2001]:

- determination of ontology classes;
- organization of classes into a taxonomic hierarchy (subclass – superclass);
- determination of attributes (properties) and description of values available for these attributes;
- filling in the attributes of an instance.

If the problem may be represented within terms of result *R*, given data *D*, solution method *M*

$$Z = \langle R, D, M \rangle, \quad (9)$$

then the ontology must include all alternative ways of representation of results, data, solution methods, data obtaining methods, data storage etc. Such information must be organized in structures which permit the usage of ontology. This applies both Ψ (organizational component) and *T* (technical component).

Let us take a closer look at *T*, a *CBG* component the implementation of which creates several problems such as the issue of representing students activity and the issue of activity management according to the logic of the domain that serves the purpose of developing given level of competence.

The solution of this problem, as shown in [Викентьева, 2013], is closely related to the separation of *CBG* into automate and operational models. Automate model is built considering the scenario, the graph of the unified management process and domain ontology. Whereby, a language must be chosen that allows to implement the management algorithm. Such languages include, for example, the language of algorithm flow-charts (*AFC*).

The graph of the unified management process and domain ontology are used to develop the operational model.

Scheme for the Development of Competence k^b

The major purpose of CBG is to develop a given level of competence k^b for the Player. To reach this goal the Player interacts with the simulator (technical component *T*), which includes the automate and operational model, testing system and the traceability competence matrix of the *EBP*. In addition, the Player uses elements related to human activity Ψ (teaching materials and software application packages), which are used to support Player's activity during the game. A particular set of application packages depends on the model of the *EBP* and competence k^b. The competence matrix is used to choose a CBG scenario that allows to develop given set of competences.

In Fig. 1 uses the following notation:

k^b – developed competence;

PG – procedural guidelines;

P – a player, players or a group of people who seek to develop their competences;

OM – operational model, interactive part of the CBG's hardware;

AM – automate model, management part of the CBG's hardware;

TS – testing system, that includes parts of CBGS and allows to construct testing recourses to conduct test transactions;

CM – competence matrix;

SAP – software application packages.

Let us take a closer look on the cooperation of CBG elements while developing competence k^b (Fig. 1).

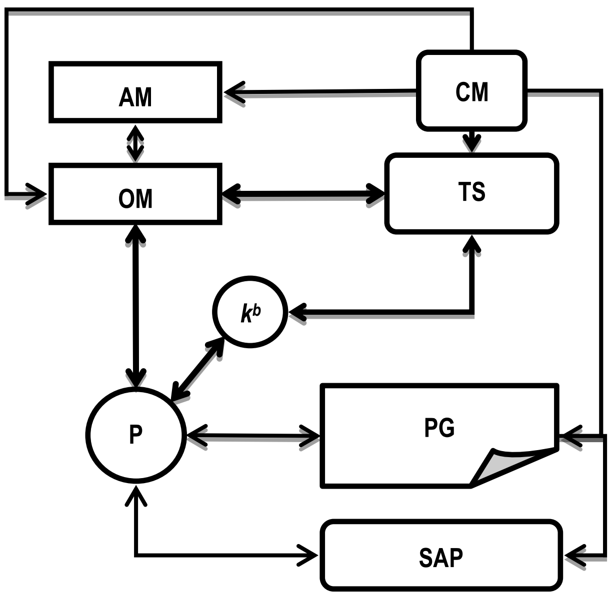

Fig. 1. Cooperation of *CBG* elements while developing competence k^b

On the stage of *CBG* elements' development competence matrix determines structural, algorithmical and functional properties of the automate model, operational model, testing system, procedural guidelines and software application packages.

Competence matrix is represented by the following relation:

$$CM =< k^b, G_i^U >, \tag{10}$$

$$CM =< k^b, U_i^U >, \tag{11}$$

where G_i^U – paths in *EBP* graph,

U_i^U – paths in the graph of the educational management business process.

Determination of CBG elements' properties is performed by imaging CM into the model of associated element. Automate model may be represented as the management algorithm in the language of algorithm flow-charts. The determination of algorithmical and structural properties of the AM in algorithm L may be represented as follows:

$$CM \rightarrow L(P, A, \Omega, \uparrow_i, \uparrow_i), \tag{12}$$

where $\rightarrow$ – imaged into,

P – test statements (the value of state register, CBG state code),

A – control signals, which determine conduction of transactions,

Ω – unconditional go-to statements,

$\uparrow i$ – transition beginning statements of the *i*-th arrow,

$\downarrow i$ – transition ending statements of the *i*-th arrow.

The algorithmical and structural properties of the operational model are determined by following imaging:

$$CM \rightarrow Q(R,TR,T), \quad (13)$$

where *Q* – function, implemented by the OM,

R – recourses,

TR – testing recourses,

T – transactions.

The “recourse” term refers to information structure, which is required to construct to CBG context and to interact with Player. Recourses may be of two kinds:

- competence development recourses *R;*
- competence evaluation recourses *TR.*

Transaction is a group of logically unified operations that works with data and is either completely processed or completely cancelled. *CBG* transaction includes:

- receiving of control signal from AM;
- choosing recourse;
- information output for the Player;
- standby and Player’s reaction input;
- processing Player’s reaction input;
- setting the state register.

Testing system includes methods and ways to construct testing recourses *TR*, information about developed competences $I(k^b)$, domain ontology *O.*

TR construction may be represented as follows:

$$CM \rightarrow TS(TR, I(k^b), O), \quad (14)$$

where *TR* – testing recourses,

$I(k^b)$ – competence information,

O – domain ontology.

PG construction may be represented as follows:

$$CM \rightarrow PG(S, In, Re, Mp), \quad (15)$$

where *S* – standards,

In – instructions,

Re – regulations,

Mp – technical guidelines.

Software application packages are chosen in accordance with the following expression:

$$CM \rightarrow SAP(P_j), \quad (16)$$

where P_j – array of SAP identification numbers.

During the game, *AM* control signal are used by elements of *OM* to construct *CBG* context as well as conduct educational or test transactions for the Player. By analyzing transaction information the Player performs actions that develop competences. *CBG* state is coded by the operational model in state register (*SR*) according to Player’s reaction. This code is used by the automate model to create new control signals.

While analyzing information received from *OM* the Player may use procedural guidelines as well as software application packages.

The analysis of the process of competence k^b development along with its level evaluation is performed with the aid of test transactions sequence. These transactions are formed by the operational model either consecutively or concurrently with educational transactions.

During the game, a part of testing system is used to evaluate the level of competence, that has been developed. This part includes testing recourses which are loaded to the *OM* in advance.

Thus, following items may be distinguished:

- circuit that develops and evaluates competences, and includes player, developed competence k^b , operational model and testing system;
- circuit of *CBG* management, which includes automate and operational models;
- subsystem of player activity support, which includes procedural guidelines and software application packages.

CBG Operational Model

The game player implements a lot of sets of transactions to reach a certain level of chosen competences.

Competence development happens when the Player interacts with the technical part of CBG, main element of which is the operational model (Fig. 2).

In Fig. 2 uses the following notation:

AMI – automate model interface,

UI – user interface,

TSI – testing system interface,

CMI – competence matrix interface,

DP – diagnostic processor,

GP – gaming processor,

RS – recourse storage,

TRS – testing recourse storage,

SR – state register.

Figure 2 shows that OM is connected with CM, TS, AM and the Player. Connections are implemented with the aid of interfaces (means of interaction).

The structure of *OM* gives much attention to the state register. *SR* saves the code of *CBG* state, which refers to a number, associated with context of the game, transaction state, developed competences and Player's reaction.

AM read the state code via *AMI* analyzes it and creates an array of control signal that are then output via *AMI* to the gaming and testing processors.

According to the the value of the management action gaming and testing processors conduct game or test transactions.

Recourse storage and testing recourse storage aim to store date of different type: text, multimedia, geospatial information, etc.

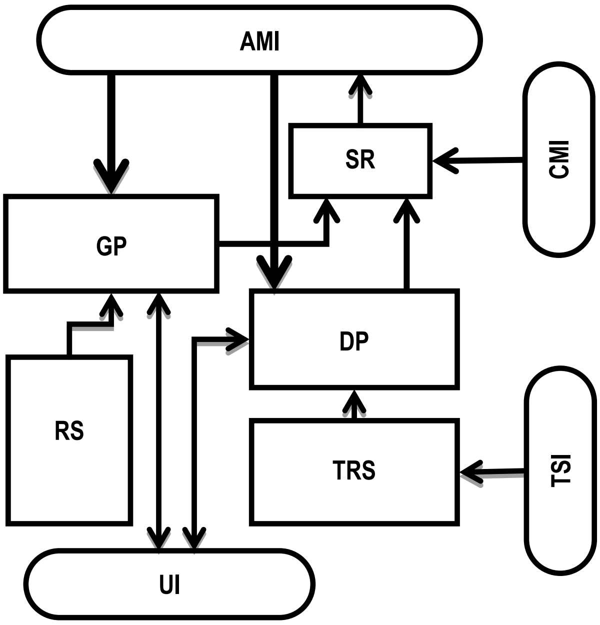

Fig. 2. Structure of CBG operating model

When conducting transactions, processors convert combinations of recourses into information structures that interact with *CBG* participant. Information, received by the Player, gives him incentives for analysis and generalization. The result of these actions represents the developed competence.

Conclusion

To effectively support organizations with qualified experts new systems of competence development need to be introduced. Thus, article gives a description of eragtic system's structural elements. The system is a competence-based business game that aims to develop professional competences.

Domain's (company's) business processes are represented in a form of oriented graph, traversing of which allows to develop elementary competences. *CBG* uses graph models of educational and management business processes. Moving on to the *EBP* models requires system analysis and domain ontology construction to be performed.

Business game includes technical and organizational components. The implementation of technical component requires CBG to be divided into automate and operational models. Technical component forms sets of transactions, which mean the player to develop a certain level of competences.

The cooperation of *CBG* elements distinguishes a circuit of competence development and evaluation and a circuit of management. The organizational component is required to support player's activity during the game.

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