The development of ontological model for increasing the competitiveness of university graduates in information technologies

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Abstract. The relevance of this work is supported by the need to ensure the professional training compliance with both formal and informal requirements of the education system and the labour market. A lack of methods and technologies being able to harmonize the outcome of the information technologies curriculum and the labour market demands is the reason why the university graduates find it difficult to compete on the labour market. The paper describes the method for an ontological model development that would be able to form the content of the IT-competencies and to assess them in the university students. It is based on two thesis: the first, the boundaries of the subject area of competencies should be defined and, the second, a method of taking into account individual characteristics and needs for creation of an individual professional training and self-study plan should be preliminary considered and developed. The article presents the ontological model developed by the stated method to form the content of the IT-competencies and to assess them for the case of the subject area of 1C: Enterprise platform business solutions. The knowledge base created by the ontological model can be integrated into the decision-making intelligence information systems intended for the sphere of education, corporate training and HR management. This article is aimed at the professionals developing new tools and methods for management of distance education and distance learning.

1. Introduction
The relevance of this work is determined by the leading role of the IT-technologies in modern society and production development. In such circumstances, the technologies become more "common", i. e. every specialist in the industry should have the specific IT skills, while the requirements to the IT-specialist competencies are steadily growing. The professional training for the IT industry is regulated by various normative and advisory documents related to competencies, qualifications, educational and occupational standards.

However, it seems hardly possible to apply all these standards at the same time as their requirements for the learning outcome of the IT-specialists can be more or less detailed and have different representations of the same aspects, de-spite the fact that they have been developed by the same method of the competency-based approach. In addition, the development of an educational program currently requires to take into account both the federal educational standards and the occupational ones. It makes the issue of their compatibility more relevant.

A lack of methods and technologies being able to harmonize the IT training results and the labour market demands set a course for developing methods to resolve the issue using the theory of knowledge
management and engineering. The theory was used to form the content of the IT-competencies and to assess them in the IT-specialists for the case of the subject area of 1C:Enterprise platform business solutions.

2. Methods
At this point a strong theoretical base for ontological modelling has been gained. The definition of ontology may refer to a mind-set, a world view, "basic premises of some discipline" (theory, school of thoughts), the "core" of scholarly tradition, paradigm or research program, a basic knowledge model (for subject area), and a set of basic categories and concepts that describe the subject area [1].

From a different point of view, in terms of artificial intelligence, the ontology is a formally described and conceptualized knowledge [2]. The ontologies provide a dictionary for knowledge exchange and representation. It may be dedicated to the particular subject area and the various connections between terms in the dictionary [1].

The ontologies are often used as:
- a subject area dictionary. The ontology contains a general terminology base of the subject area, therefore, software developers can use terms from the ontology in product documentation and user interfaces, including multilingual user interfaces [3];
- database projection. The ontology provides a set of basic subject area terms that can be used for any measurement [4-9];
- a data storage format. The properties of ontological terms define the content and format of the metadata contained in the system representation [10];
- a data exchange format. The ontology-based formats of open data exchange with external systems significantly limit the complexity of the system integration when the systems have been created in various fields or developed by different developers [11-13].

3. Results
Let us assume that the development method for the ontological model aimed to form the competencies content and to assess them in the university students in relation to the subject area of 1C:Enterprise platform business solutions should be based on a system of invariant and variable requirements for the competencies of IT-specialists set in the corresponding documents (figure 1). For the purpose of this paper, the invariant requirements are the occupational standards and the documented requirements obligatory for the main education program - Federal State Educational Standards of Higher Education (FSES HE). The variable requirements play an important role in narrowing the subject area. In this case, we imply the documents forming the professional competences of 1C: Enterprise 8 platform business solution for WorldSkills.

Accordingly, the following ontology modelling method was developed. It consists of seven stages.

Stage 1. Set the boundaries of the competencies subject area for which the content and assessment tools are being formed on the basis of a harmonized normative framework.

To set the boundaries of the subject area the program of the Applied Informatics (code 09.03.03) is used.

At this stage, the concepts from all related standards should be added to the ontological model and the connection between all related standards should be made.

Stage 2. Make sure that the content of competencies is one step ahead by structuring and ranking the requirements of stakeholders as a system with interacting and opposing elements of the educational environment and the labour market.

At this stage, the concepts from the disciplines that form the competencies of the 1C:Enterprise 8 platform business solutions subject area should be added to the ontological model. The concepts of exam materials to assess the competencies and the resources that will help students develop their competencies are created.
Stage 3. Develop the concepts and their interconnections that enable the method of taking into account individual characteristics and needs for creation of an individual professional training and self-study plan. In other words, at this stage, it is possible to apply the developed ontological model to create an individual learning plan.

The individual learning plan will be formed according to the following rules. The student passes the entrance test. It helps to assess his initial competency level in the field. After that, the student is provided with a small selection of topics and links to training resources. It allows him to get an insight into all the existing variety of materials that can be later used for more specific self-study.

In the end, the student should also pass the final assessment. The results will be used in the portfolio of all competencies (figure 2) mastered using the provided educational resources. In figure 2: GPC - General Professional Competency, which described in the federal educational standard of higher education; WS - WorldSkills Championship Competencies.

If the student has successfully passed the final assessment, it means that he is interested in the field and is recommended to continue the study in more details but of an independent base. If the student has failed the final assessment, he or she can either repeat the course or select a new topic more related to his or her new goals.

Stage 4. Create the concepts for describing the resources outside the scope of the competences related to 1C: Enterprise 8 platform business solutions. It allows the student to fully comprehend his or her profession specifics and possibly adapt his/her professional development plan.

This section describes the development of the ontological model intended to form the content of the competencies related to 1C: Enterprise platform business solutions and to assess these competencies in the university students. The method stated above was used in the development.

In accordance with the method, the model development started with creation of the concepts of invariant and variable documents, which was followed by adding of some more information about the selected concepts. The ontological model was created in the Protégé software based on the frame representation of knowledge. For the sake of convenience, the authors will further use the Protégé software terms: the term concepts will be substituted with classes and subclasses.

In the framework of the set task, these classes are sufficient to gain the 1C: Enterprise platform business solutions competency.
Figure 2. Portfolio sample.

The subclasses of occupational standards will be the same in terms of the subclass structure. All classes are interacting with each other directly or transitively via slots. The model meets the requirements for the ontological models creation:

- the subject’s ontology includes the conceptual terms with the structure that can be applied to the IT-specialists training within the subject area;
- new elements can be added to the conceptual terminology (terms, connections, etc.) if the terminology consistency is maintained.

The created classes and general scheme of the developed ontological model is shown in figure 3.

4. Discussion

The competence paradigm designated as the main one in formal and non-formal education systems is designed to impose requirements for the level and content of IT-specialist training program results. However, the education system and the labor market implement the competence approach incoherently. This is the cause of a large number of normative and advisory documents imposing requirements for the learning outcome and level of the IT-specialists qualification: at the state level in Federal State Education Standards (FSES3+) and occupational standards (Information & Computer Technologies Industry Association (AP-KIT)), at the international level in international education standards, competencies and qualification frameworks. The search for the ways of integration of these requirements is a persistent problem for the formal and informal education systems [3-5].

The presented model can provide the basis for the development of a general scope ontological model that integrates formalized requirements. Further, the model can be exported to XML or other formats and become a knowledge base for an intelligent decision-making system as part of a formal and informal IT-education system.

This system will be a strong intellectual and technological base to support the specialists involved in the training of the competitive personnel for the IT-industry in the system of formal and non-formal
education. It can also be applied to obtain new scientific results (in the development of new methods and knowledge management models, general and specific training approaches for adaptive management of the learning outcome; in the design and development of new methodological approaches; in the development of normative models of approaches) and in order to try the research findings in practice (in the development of the educational and occupational standards, competencies and qualifications, educational programs for formal and informal education, designing assessment and certification systems, individual learning and professional development plans; in the development of intelligent information decision-making systems for IT-education) [12-13].

Figure 3. A figure caption is always placed below the illustration. Short captions are centered, while long ones are justified. The macro button chooses the correct format automatically.

5. Conclusion
The developed ontological model corresponds to the stated objectives: it ensures that the graduates are competitive in the field of information technologies; it also harmonizes the training requirements for the IT-specialists in the specific subject area; fulfils the requirements for the support of the educational program development; and provides an opportunity to create individual learning plans. In addition, the ontological model can be extended and applied to the certified vendor exams preparation, for example, 1C Professional exam; other training programs can be added to the model and etc. However, in order to keep the ontological model up to date the changes in the normative documents, both variable and invariant, as well as the changes in additional materials should be constantly monitored, because the labour market and the technologies are constantly developing. Therefore, we can draw a conclusion that the ontological model should be maintained and the data should be systematically updated.

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