Ontological Model of Educational Programs in Computer Science (Bachelor and Master Degrees)

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Abstract— In this work there is illustrated an ontological model of educational programs in computer science for bachelor and master degrees in Computer science and for master educational program “Computer science as second competence” by Tempus project PROMIS.

Key words: Ontological Model, Semantic Modelling, Educational Programs, Computer Science, Second Competence

I. INTRODUCTION

Artificial intelligence methods are used everywhere, including in the development of educational programs. Their use allows to introduce systematic educational model, taking into account the semantic relationships to trace causal relationships and the achievement of educational outcomes.

The modular training program is the main document which reflects the content of OP, outlines the structure of the educational program and contains a list of modules. OP includes mandatory and elective modules, coursework, practice and diploma work. Mandatory modules are set by state regulations, and elective modules are installed, based on development of science and technology and the labor market demand.

In accordance with the purpose of OP "5B060200 -" Computer science "the content of the curriculum is aimed at obtaining broad fundamental knowledge and skills in the field of computer science. The first is achieved by studying the fundamental modules, which complies with the recommendations in the Computer Science Curricula 2013, Computing Curricula 2005 [1,2] , depicted on pic. 3, where shaded portion represents the computer science discipline. Computer science covers most of the vertical space between the extreme top and extreme bottom because computer scientists generally do not deal with just the hardware that runs software, or just the organization that makes use of the information that computing can provide. As a group, computer scientists care about almost everything in between those areas (down as far as the software that enables devices to work and up as far as the information systems that help organizations to operate). They design and develop all types of software from systems infrastructure (operating systems, communications programs, etc.) to application technologies (web browsers, databases, search engines, etc.) Computer scientists create these capabilities, but they do not manage the deployment of them.

II. THE ONTOLOGICAL MODELS OF EDUCATIONAL PROGRAMS IN COMPUTER SCIENCE

Ontology is a powerful and widely used tool to model relationships between objects belonging to various subject fields. It is possible to classify ontologies based on the degree of dependence on the task or application area, the model of ontological knowledge representation and expressiveness, as well as other criteria.

A body of formally represented knowledge is based on a conceptualization: the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them (Genesereth & Nilsson, 1987) . A conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose. Every knowledge base, knowledge-based system, or knowledge-level agent is committed to some conceptualization, explicitly or implicitly.

Ontology is an explicit specification of a conceptualization. The term is borrowed from philosophy, where Ontology is a systematic account of Existence. For AI systems, what "exists" is that which can be represented. When the knowledge of a domain is represented in a declarative formalism, the set of objects that can be represented is called the universe of discourse. This set of objects, and the describable relationships among them, are reflected in the representational vocabulary with which a knowledge-based program represents knowledge. Thus, in the context of AI, we can describe the ontology of a program by defining a set of representational terms. In such ontology, definitions associate the names of entities in the universe of discourse (e.g., classes, relations, functions, or other objects) with human-readable text describing what the names mean, and formal axioms that constrain the interpretation and well-formed use of these terms. Formally, an ontology is the statement of a logical theory[3, 4].

Applied ontologies describe concepts that depend on both the task and the subject domain of the ontology.

An applied ontology is based on general principles of ontology building, and semantic hyper-graphs are used as a model for knowledge representation. This formalism determines ontology O as triple (V, R, K), where V is a set of concepts of a given subject field, R is a set of relationships between these concepts, and K is a set of names of concepts and relationships in the domain [5,6,7,8].

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We used the ontology editor Protégé (http://protege.stanford.edu) to build the ontology. It is a free open source ontology editor and a framework for building knowledge bases. It was developed at Stanford University in collaboration with the University of Manchester.

III. THE ONTOLOGICAL MODELS OF EDUCATIONAL PROGRAMS IN COMPUTER SCIENCE BACHELOR DEGREE

The content of the modular educational program, by main substantive directions, meets ACM curriculum and requirements of European quality assurance agencies on computer science. The chosen approach on ontological modeling allows formally describe the structure of the educational program and its content via logical links, discover possible training trajectories, and correlate educational program goals with learning outcomes

Figure 1 illustrates the concepts and relationships which is used in the ontological model bachelor degree in computer science.

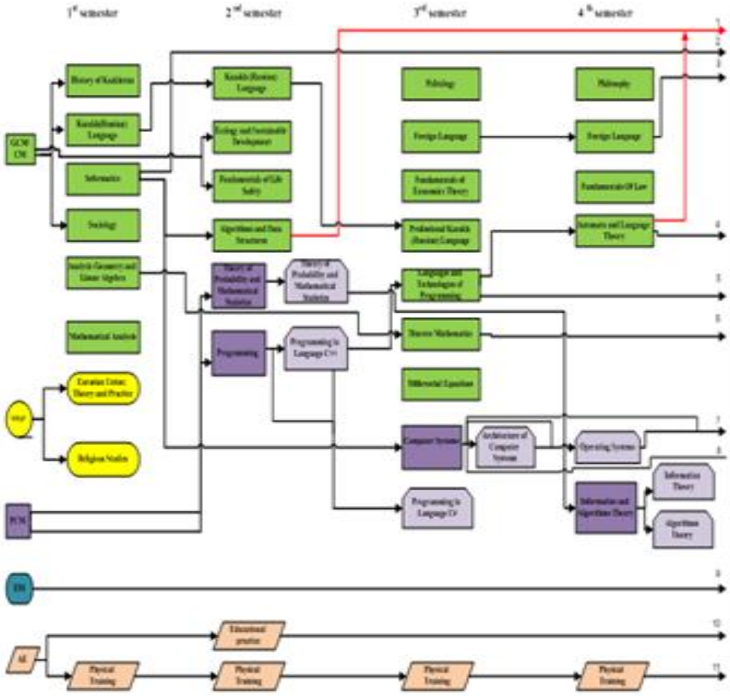

Fig. 1: The ontological models of bachelor degree in computer science (1-4 semesters)

Figure 1 shows a fragment of the ontological model, where the model of educational program has been augmented by some semantic clarifications, which are highlighted by color and geometric shapes. For example, green represents mandatory modules in the social sciences (sociology, law, foreign languages, etc.). The purple color means mandatory specialty modules (programming, computer systems). Lighter color means the disciplines, included in the module. There is time axis on the the top of the figure (1 semester 2 semester ... 4 semester). The arrows indicate the relationships between modules. Beige color in the parallelogram denotes additional training modules: physical education, training practice.

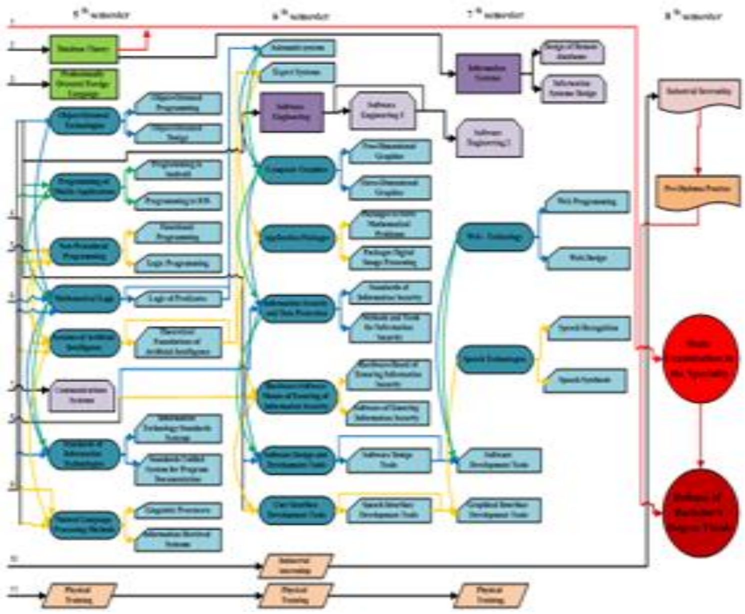

Fig. 2: The ontological models of bachelor degree in computer science (5-8 semesters)

Figure 2 shows a fragment of the ontological model of 5-8 semesters. For example, turquoise color means elective modules; there is a time axis on the top of the figure (5 semester, 6 semester, 8 semester). The arrows indicate the relationship between modules. Beige color in the parallelogram indicates additional training modules: physical education, industrial internship, pre-diploma practice. The red color shows the state examination in the specialty, defense of Bachelor's degree thesis. Yellow, green and blue arrows display the possible learning paths.

IV. THE ONTOLOGICAL MODELS OF EDUCATIONAL PROGRAMS FOR MASTER EDUCATIONAL PROGRAM "COMPUTER SCIENCE AS SECOND COMPETENCE" BY TEMPUS PROJECT PROMIS

Tempus PROMIS project is a continuation of the Tempus project ERAMIS. Currently, master's programs are being launched in Uzbekistan, Tajikistan and Turkmenistan, Kazakhstan (Astana) and Kyrgyzstan (Osh). The master's program "Computer science - second competence" (different from the usual master programs in computer science, because it is designed for people with a bachelor's degree program, unrelated to computer science. This fact determines the main structure and content of the educational program.

Mandatory modules of educational program have been recommended by the coordinators - representatives of the University Pierre Mendes France and include: algorithms and data structures, mathematics for computer science, databases, operating systems and networks, Web development, project management, human computer interaction, data mining and data warehouses, software engineering. Besides mandatory modules we included elective modules: web language, social network. The approach allows the ontological modeling to formally describe the structure of the educational program and its content via logical links, to show the possible trajectories of training, to match educational program's goals and learning outcomes.

Figure 3 illustrates the concepts and relationships which are used in the ontological model master degree "Computer science as second competence" by Tempus project PROMIS

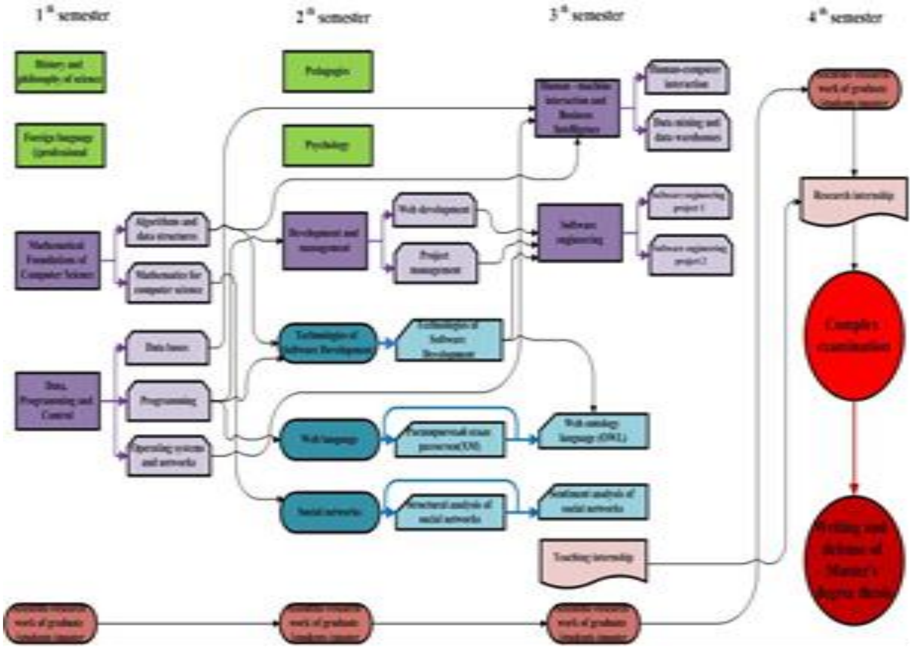

Fig. 3: concepts and relationships which are used in the ontological model master degree "Computer science as second competence" by Tempus project PROMIS

As in the previous example, green represents mandatory modules in the social sciences, purple color means mandatory modules in the specialty. At the top of the figure there a time axis (1 semester 2 semester ... 4 semester). The arrows indicate the relationship between modules. Beige means practice and research work in the red circles mean the complex examination in the specialty, writing and defense of a thesis.

V. FORMALIZATION OF ONTOLOGICAL MODELS OF TRAINING TRAJECTORIES

Models, derived in chapter 2 allow for scripting of all possible training trajectories by mean of formal notation.

A. Formalization of ontological models of training trajectories in bachelor program on computer science

Let us assume the following notations:

A is a set of mandatory modules on regulatory documents, B is a set of mandatory modules on specialty, C is a set of elective modules, D is a set of additional modules, E is a set of final modules.

- C1 is a subset of elective modules for trajectory «Computer linguistics», C1 = {c1,c5,c7, c9,c11,c13,c15}, where $C1 \subset C$.
- C2 is a subset of elective modules for trajectory «Programming» C2 = {c1,c4,c6, c8,c10,c12,c14}, where $C2 \subset C$.
- C3 is a subset of elective modules for trajectory «Programming engineering» C3 = {c2, c4, c6, c8,c10,c12,c14}, where $C3 \subset C$.

Then bachelor program on computer science could be represented as a set of the following functions:

$$k(A,B,C1,D,E)= A \cup B \cup C1 \cup D \cup E$$
$$l(A,B,C2,D,E)=A \cup B \cup C2 \cup D \cup E$$
$$m(A,B,C3,D,E)=A \cup B \cup C3 \cup D \cup E$$

B. Formalization of ontological models of training trajectories in master program on Computer Science as a second competence – TEMPUS/PROMIS program

Let us assume the following notations:

A is a set of mandatory modules on regulatory documents, B is a set of mandatory modules on specialty, C is a set of elective modules, D is a set of additional modules, E is a set of final modules.

- C1 is a subset of elective modules, where $C1 \subset C$.
- C2 is a subset of elective modules, where $C2 \subset C$.

Then master program on Computer Science could be represented as a set of the following functions:

$$k(A,B,C1,D,E)= A \cup B \cup C1 \cup D \cup E$$
$$l(A,B,C2,D,E)=A \cup B \cup C2 \cup D \cup E$$

VI. CONCLUSION

The results obtained here, allow to represent educational programs in computer science in the form of ontological models, that is, to show the logical relationship, taking into account the semantics trace causal relationships and the achievement of educational outcomes. This approach allows us to follow the objectives of the program, the formation of the necessary competencies to adjust the structure and content of the educational program at the design stage. The next step after the ontological modeling is the formalization of the possible educational trajectories in the form of records. This eliminates errors in the registration process on the discipline is not necessary adviser presence the time of registration. The system monitors the selected educational trajectory by means of formal records in the knowledge base of the system. This system is being developed as part of the Virtual University project intelligent system of training, monitoring and evaluation of knowledge.

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