ONTOLOGY OF EDUCATIONAL STANDARDS

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Abstract: *This article discusses the formation of educational standards. The method of forming the content of the educational process describes. The method is based on the ontological knowledge representation and ontological models describing different categories of educational process. Is an example of the formation of educational and vocational programs educational qualification level, the allocation of appropriate skills competencies, creating curricula based on application of an ontological description of subject knowledge.*

Keywords: *ontology, knowledge systems, educational programs, ontograph.*

ACM Classification Keywords*: G.2 Discrete Mathematics – G.2.2 Graph Theory – Trees; I.2 Artificial Intelligence - I.2.4 Knowledge Representation Formalisms and Methods; K.3 Computers And Education – K.3.2 Computer and Information Science Education*

Introduction

Quality of training of skillful specialists in various areas of human activity depends on its content. The content factor of educational process is determined by the following categories:

- National qualification system is an aggregate of mechanisms for legal and institutional regulation of employee's skills taking into consideration the needs of labor market and capabilities of education system;
- Qualification levels are the requirements, determined and adopted under procedure established by legislation, to competence of employee when performing job responsibilities considering their complexity and level of responsibility.

The full-scale content disclosure of such categories is implemented on the basis of national framework of skills (NFS) — systemic and structured description of skills, educational and qualification levels, qualification standards of various levels and types established on the basis of criteria set determined by law. NFS determines the single scale of qualification levels of generally professional competences to develop the sectoral framework of skills and professional standards. NFS ensures inter-sectoral comparability of skills and competences; it is a basis for system with regard to confirmation of compliance and awarding the qualification to specialists. The national framework of skills consists of description of general characteristics of professional activity for each qualification level.

Thereby, NFS determines the dynamics of development of education standards as a definite system of norms and requirements, which describe the mandatory minimal content of main educational and professional programmes, maximal scope educational load and requirements to training level of specialists. Educational and professional programme (EPP) is a sectoral regulation, which determines the regulatory period and content of education, regulatory forms of state assessment, sets the requirements to content, scope and level of education and professional training of specialist by the subject area of training. The educational standard is an element of sectoral standards of higher education and it is used for the following activities:

- Develop and adjust the element of sectoral standards of higher education (diagnostic facilities of higher education quality);
- Develop and adjust the elements of higher education standards of higher education establishments (variation parts of education and professional programme for specialists training and diagnostic facilities of higher education quality, curriculum, programmes of subjects and practices);
- Determine the content of training within the system of retraining and improvement of skills of specialists.

Ontological description methods

Dynamics of creation and development of modern technologies require from education system new approaches when developing NFS. The main requirement of such development should be succession of content and keeping an inter-disciplinarity at the level of subject and topical filling of subjects.

One of such technological approaches is to develop an information base that contensively secures the whole educational process of specialists training in higher school on the basis of ontological simulation of information processes.

As we already mentioned, the foundation of information base to support an education process of any university are curricula, educational programmes and library resources. At present practically all these resources are electronically. Practically all manuals, tutorials, monographs and any other information materials also have their own electronic images. Each such electronic image displays a certain scope of thematic knowledge. Such knowledge, presented in the form of information descriptions as natural and language structures [Гладун, 1994], mirror the considerations about certain subject and thematic facts. The facts are linked with each other by certain relationship and could be also characterized by definite features.

In general, all educational materials and, in particular, the bookish ones are described by scientific style, which is focused on transfer of certain information or explanation of any facts from the scientific point of view. Such style uses various terms and professional vocabulary. The style is typical for educational scientific literature. Scientific style is a style of scientific messages. The area of usage of this style is science and scientific magazines, addressees of text messages could be scientists, future specialists, students and any person who is interests in this sort that scientific area; the authors of tests of the said style are scientists and specialists in their area. The purpose of style one can name the description of laws, identification of regularities, description of discoveries, training etc.

The main function of a style is to communicate information as well as to prove its truth. It is characterized by small terms, generally scientific words, an abstract vocabulary, at theta noun prevails; there is a lot of abstract and material nouns. Judgments have a type of specific expressions and determine the sets of actions, which could be applied in the process of resolving the concrete subject and thematic tasks.

Separation of a set of actions on the basis of knowledge system described and presented in book is possible provided that the procedure of structuring is applied to its natural and language text. To this end we will transform somehow the bookish text having presented it not in the usual form of information description that is consecutive and consistent by style but having represented it in an aggregate of specific statements and expressions. The concrete subject statements/expressions, which have the subject focus, could form the passive base of knowledge.

Transformation of passive base of knowledge, which is represented in the form of information descriptions set forth in the book, into the active is possible on the basis of transformation of such descriptions into the certain terminological fields [Коршунова, 2009], where the concrete notions become concepts of subject are, which is described in a book [Гладун, 1994; Палагин, 2005]. The abovementioned concepts are the certain statements, which determine the specific actions and results of such actions. The statements themselves are designed on the basis of usage of semantics of concepts and those relations, which link these concepts by certain sense.

Sets ofstatements/expressions, which are developed on the basis of subject concepts, form a certain category [Rydeheard, 1988], the objects of which have morphisms for each pair of statement-expression. In future we will consider the morphisms, which transform expressions, given in the text of book, into statements being true for the described facts. One should note that it is difficult to separate the notions “statement” and “expression”; they are practically equivalent. Such separation is fairly artificial and it is constructive in the terms of normal system theory [Malishevski, 1998], where “expression” determines a number of source or passive data; however “statements” allow to assigning and determining the specific dynamic activities. It means that we form a set of concrete subject expressions; then we represent such expressions into the form of statements rephrasing them in an affirmative form [Mendelson, 1997]. Such affirmative form will help us to formulate a certain hypothesis, which on the basis of value of concrete facts representing the displays of concrete phenomena, can be confirmed or to be proved as groundless [Kleene, 1952].

Let us formulate the following rule for expressions and statements:

a) Statement/expression is considered as applicable if there are the conditions determining its truth;

b) Statements/expressionsare considered as inapplicable if there are no conditions determining its truth.

Now we can consider the definition of computer ontology stated in the works of N. Guarino and N. Gruber [Guarino, 1994; Gruber, 1993]–where definition of ontology is considered as specification of conceptualization. The ontology includes also the systems of restrictions, which could be overlaid onto relations within the subject matter of knowledge domain and are expressed in the form of a definite set of axioms that is determined on the basis of notions-concepts and relations between them. Thereby we are able to consider the ontology as conceptually definite and established system of knowledge.

Constructively, ontology as a definite category of development and implementation of information technologies we will understand and form on the basis of definition given in the said work [Гладун, 1994; Палагин, 2005]:

- Hierarchic structure of final aggregate of notions-concepts, which describe the set knowledge domain (KD);

- Structurally ontologycan be represented in the form of ontograph, the tops of which are notions and arches are semantic relations between them;
- Notions-concepts and relationship are interpreted in accordance with the generally valid functions of interpretation taken from electronic sources of knowledge of the set KD;
- Notions and relations are determined on the basis of axioms and restrictions (rules) of their area of action;
- There is a means of formal description of ontograph;
- Functions of interpretation and axioms could be described in notation of formal theory.

Thus, ontology means something more than just detailed set of notions and relations. Therefore, one can describe ontology as an active system of knowledge, which includes an aggregate of objects, and having linked them with descriptions as well as having introduced the formal axioms restricting interpretation and joint usage of such terms. It means that ontology can be considered as some logical theory, some calculation with its own rules. This theory allows to classifying the categories of reality and/or those being expressed in the language of value. [Гладун, 1994].

In general form an ontological model can be formed and represented on the basis of the following four categories:

- Notions-concepts;
- Relations and features;
- Axioms;
- Functions of Interpretation.

Notions are considered as conceptualization of class of all representatives of some essence or phenomenon (for instance, SOFTWARE ENGINEERING, INFORMATION TECHNOLOGY, COMPUTER NETWORKS, DESIGNING OF LOCAL NETWORKS, DATA BASES, and RELATIONAL ALGEBRA etc.). Classes combining notions-concepts on the basis of certain features and relations are general categories, which could be regulated hierarchically. Each class describes the group of individual essences, which are combined on the basis of common features. The most widespread type of relations being used in all ontologies is relationship of categorization, i.e., attribution to certain category. On the basis of this type of relationship the taxonomy of text document is being set [Grossi, 2005]. Axioms and functions of interpretation specify the conditions of attribution of categories and relations and they express the concrete statements.

Now we can consider the process of development of educational and professional programm of educational and qualification level BACHELOR with respect to speciality SOFTWARE ENGINEERING and corresponding qualification SPECIALIST ON SOFTWARE DESIGNING AND TESTING.

Educational Program Ontology - example

The papers [Гладун, 1994; Палагин, 2005; Величко, 2009] describe methodologies and procedures for transformation of passive knowledge system represented in book into active ontology, which ensures information support of subject tasks of teacher and student. Thus, the Figure 1 shows a fragment of ontograph, the tops of which are notions-concepts disclosing the educational and qualification characteristics of speciality SOFTWARE

ENGINEERING. Figure 2 shows a fragment of ontograph, the tops of which determine concepts of main functional areas of the said speciality. Figures 3-a and 3-b represent a fragment of ontology of knowledge system determining the content of the respective subject and topic disciplines being used for training of specialists.

Figures 4a – 4b show the content of a top-concept on discipline SOFTWARE DESIGNING, give examples of inclusion of the respective information content of the course. Figures 5a – 5b represent a fragment of ontology related to development of credit module with regard to discipline SOFTWARE OF DATABASES being one of the courses with regard to discipline SOFTWARE ENGINEERING.

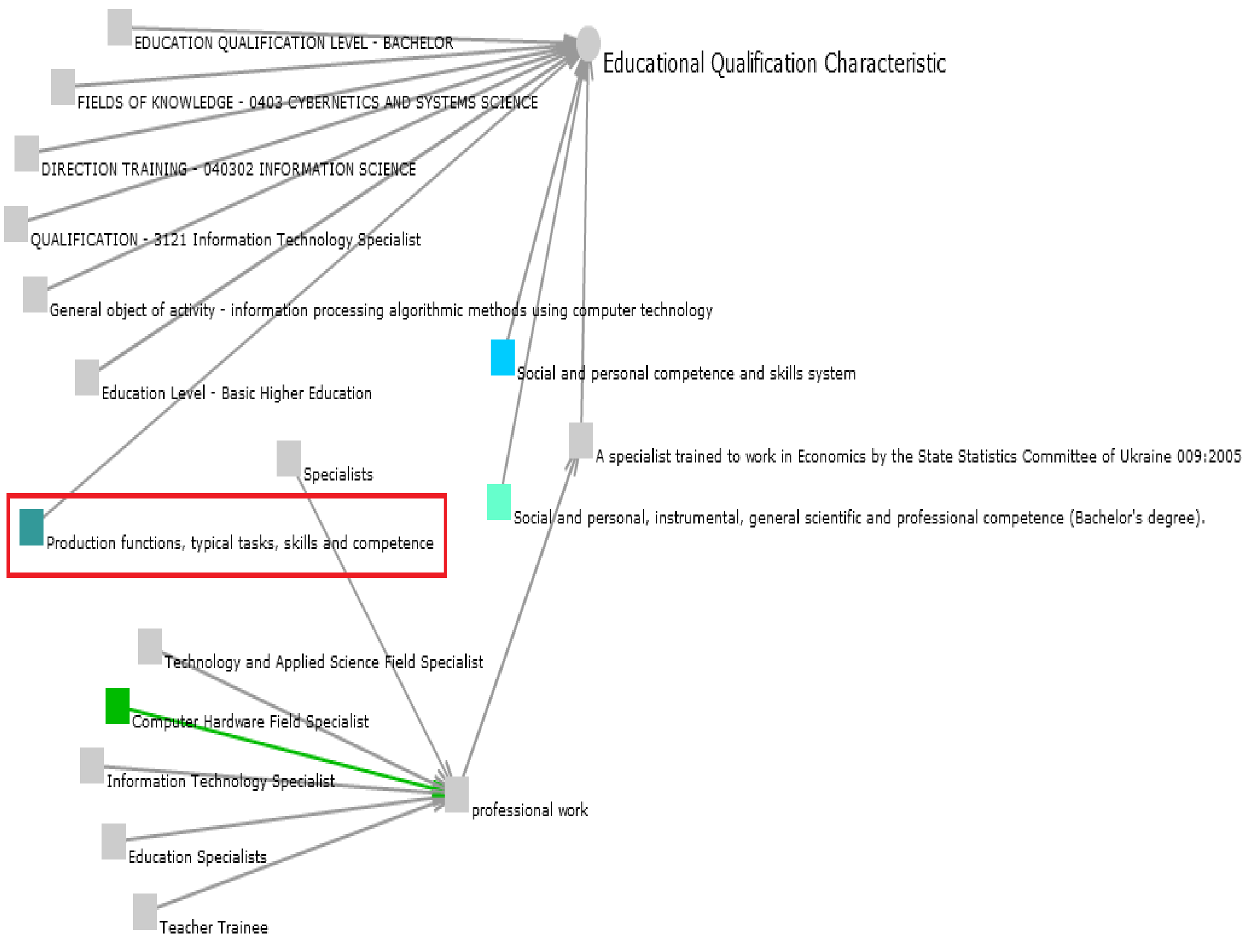

Figure1. Fragment of ontograph of educational and qualification characteristics for speciality SOFTWARE ENGINEERING

As one can see, ontograph means educational and qualification characteristics for speciality, which the skills of specialist should comply with. Ontograph should understand the business functions, be knowledgeable about modern information technologies, have the respective system of skills etc.

Let us consider the top PRODUCTION FUNCTIONS, MODEL TASKS OF ACTIVITY, SKILLS AND COMPETENCES of graduate. The content of this top-concept is shown in Figure 2 in the form of ontograph of main functional areas to be inherent in graduate.

The given fragment of ontology shows functions of software designing. The tops-concepts in this case are main skills of qualified specialist.

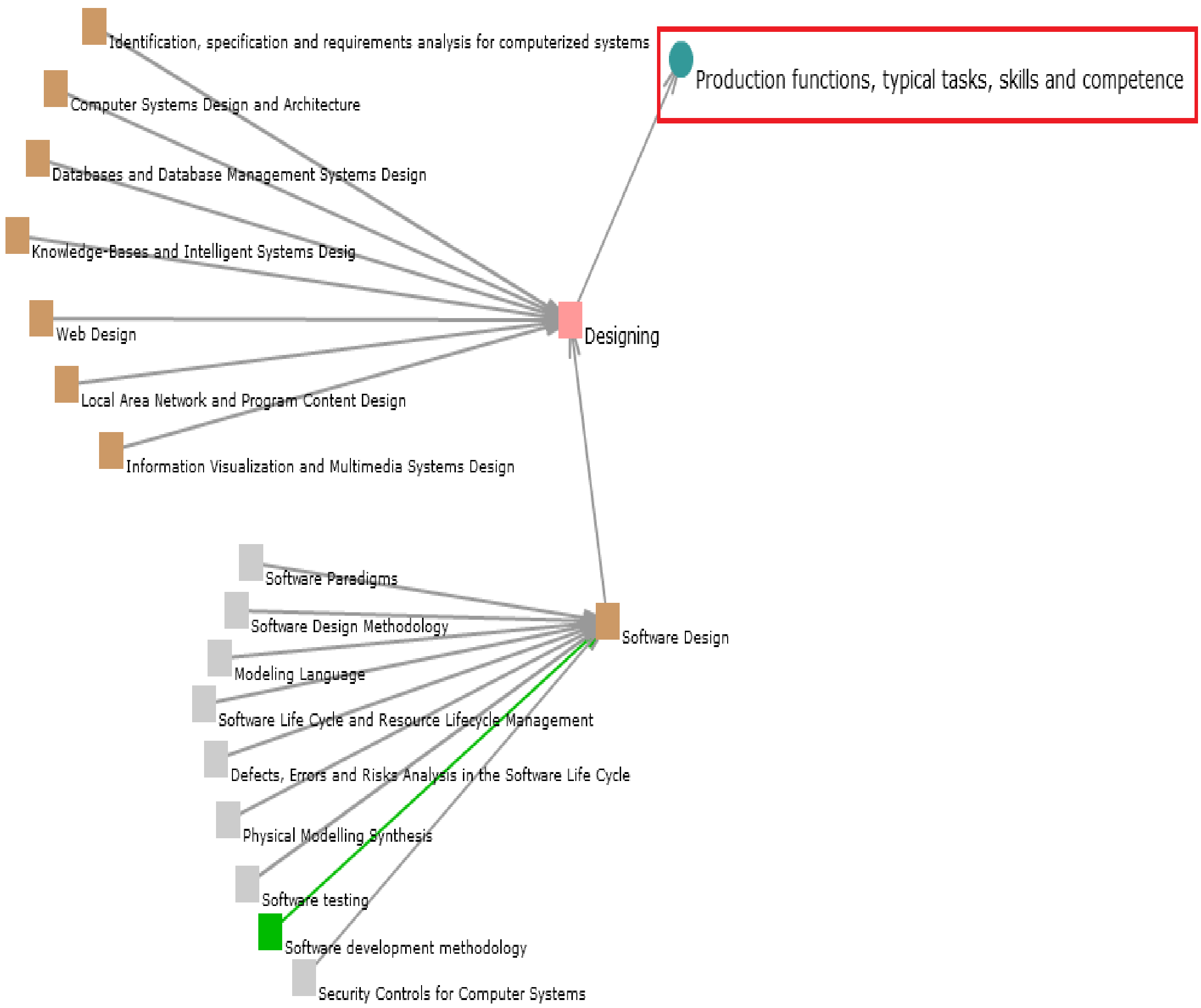

Figure 2. Fragment of ontograph of main functional area of speciality SOFTWARE ENGINEERING

The ontology shows taxonomy dependence between all categories, which determine the level of training in the area of usage of software designing mechanisms.

Figures 3a – 3b show ontology of knowledge systems (passive) on subject and topical disciplines, which comprise the complete course with regard to speciality SOFTWARE ENGINEERING.

Each top-concept determines the content of such disciplines. This content can be represented by a number of manuals, educational and methodological textbooks and monographs on subjects of concrete discipline. An example of substantive filling of ontograph tops is given in Figure 4a – 4b.

Figure 5a – 5b shows organization of credit module on one of each disciplines of speciality. The main types of educational activity on concrete subject disciplines are determined. Each discipline composes the system of knowledge on speciality. Educational load, curricula and educational programmes are being determined. And now each programme and each curriculum are supported by the corresponding information resource – monographs, methodological recommendations, tutorials etc.

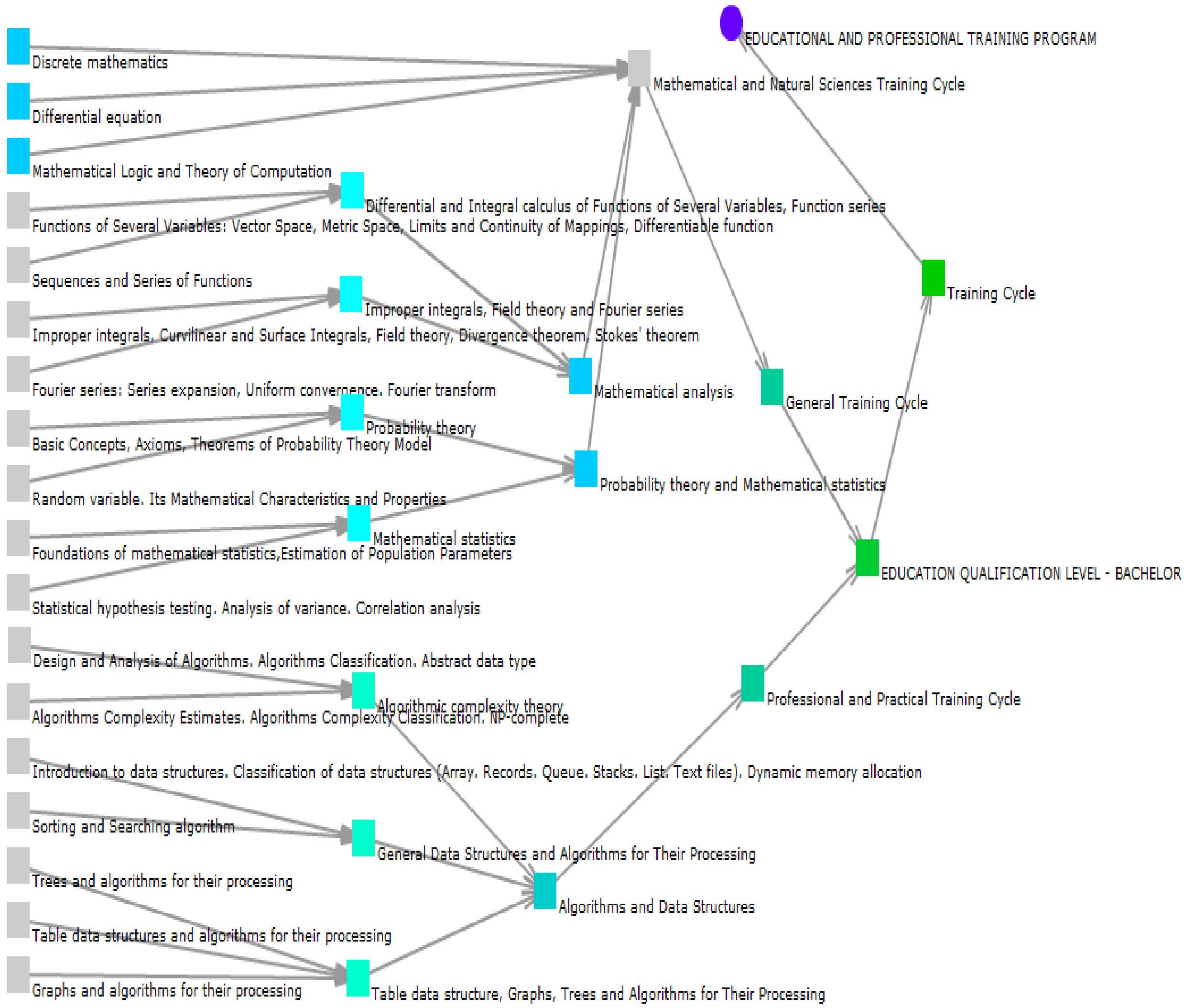

Figure 3a. Fragment of ontology of subject and topical disciplines on speciality SOFTWARE ENGINEERING.

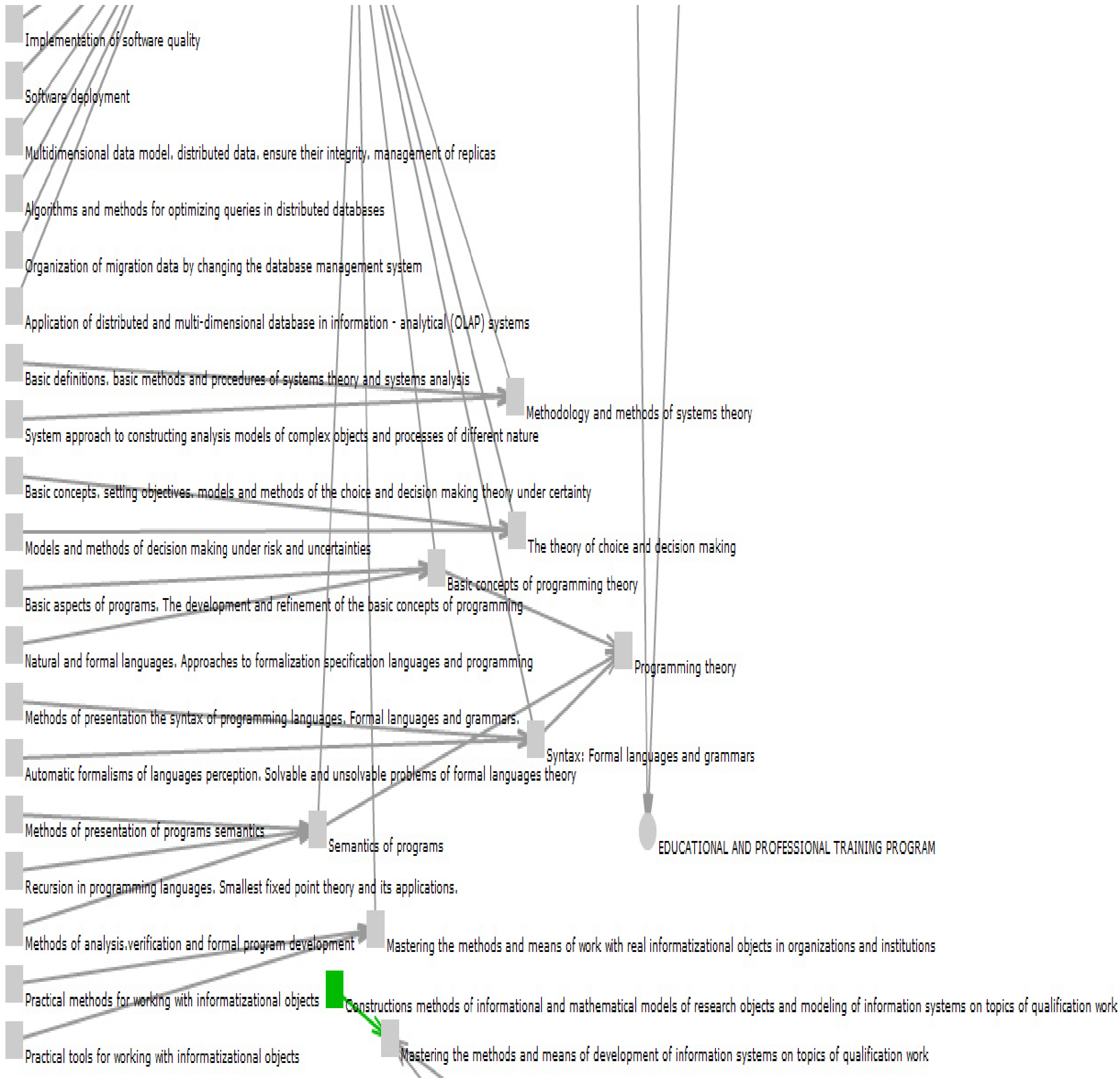

Figure 3b. Fragment of ontology of subject and topical disciplines on speciality SOFTWARE ENGINEERING (continued)

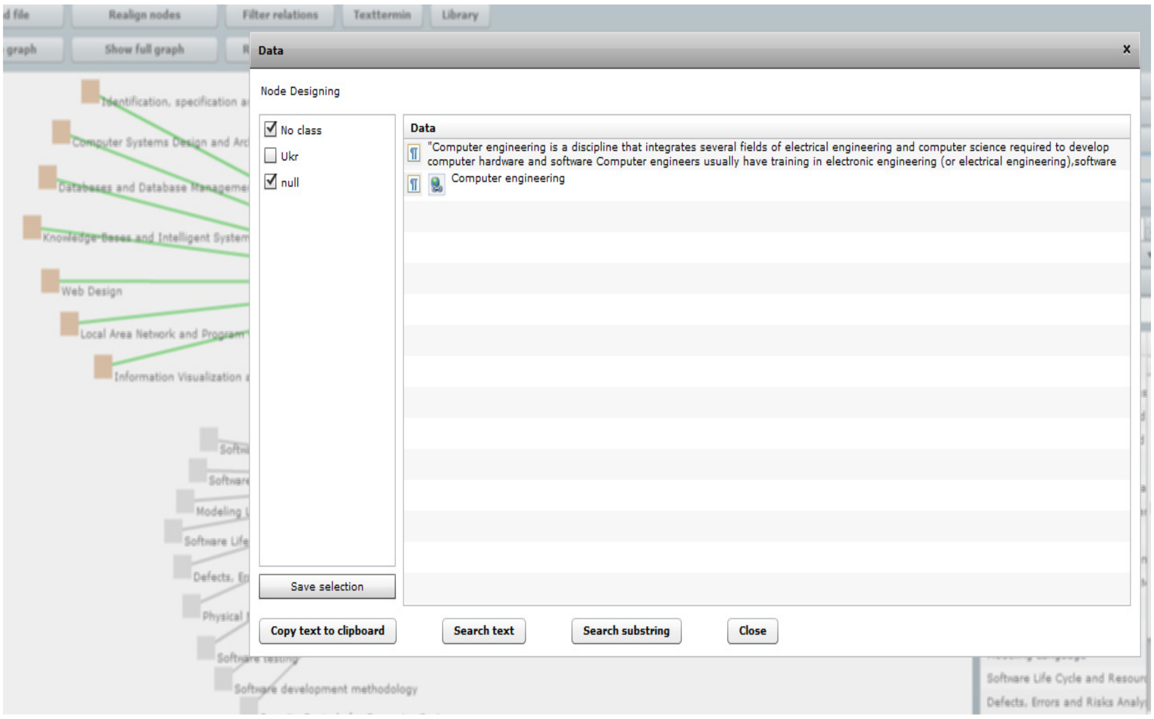

Figure 4a. Content of top-concept on discipline SOFTWARE DESIGNING

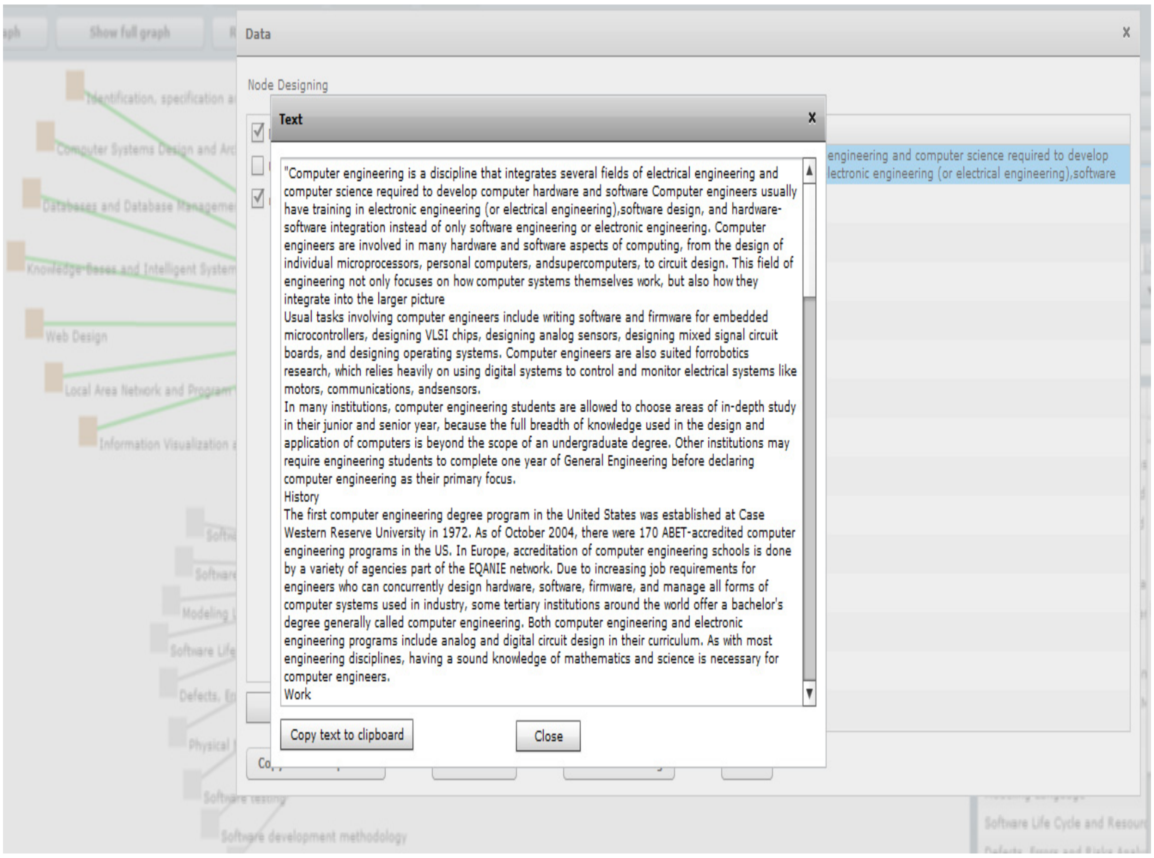

Figure 4b. Description of top-concept on discipline SOFTWARE DESIGNING

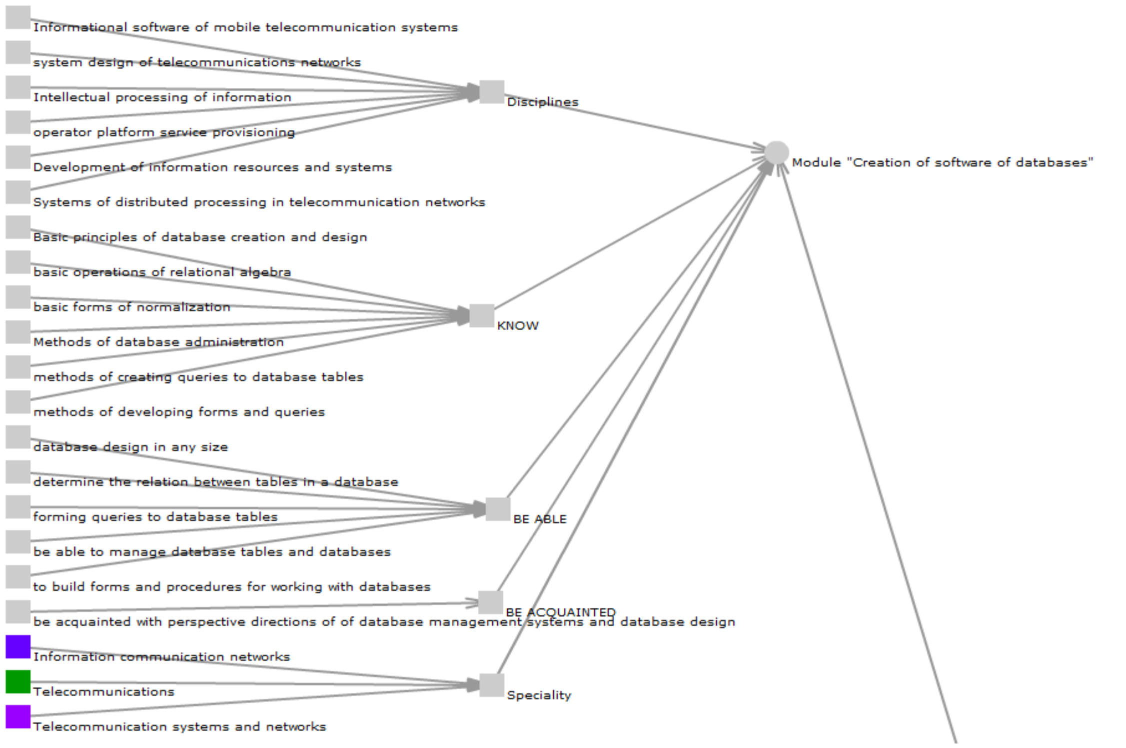

Figure 5a. Fragment of ontology to develop the credit module on discipline SOFTWARE OF DATA BASES

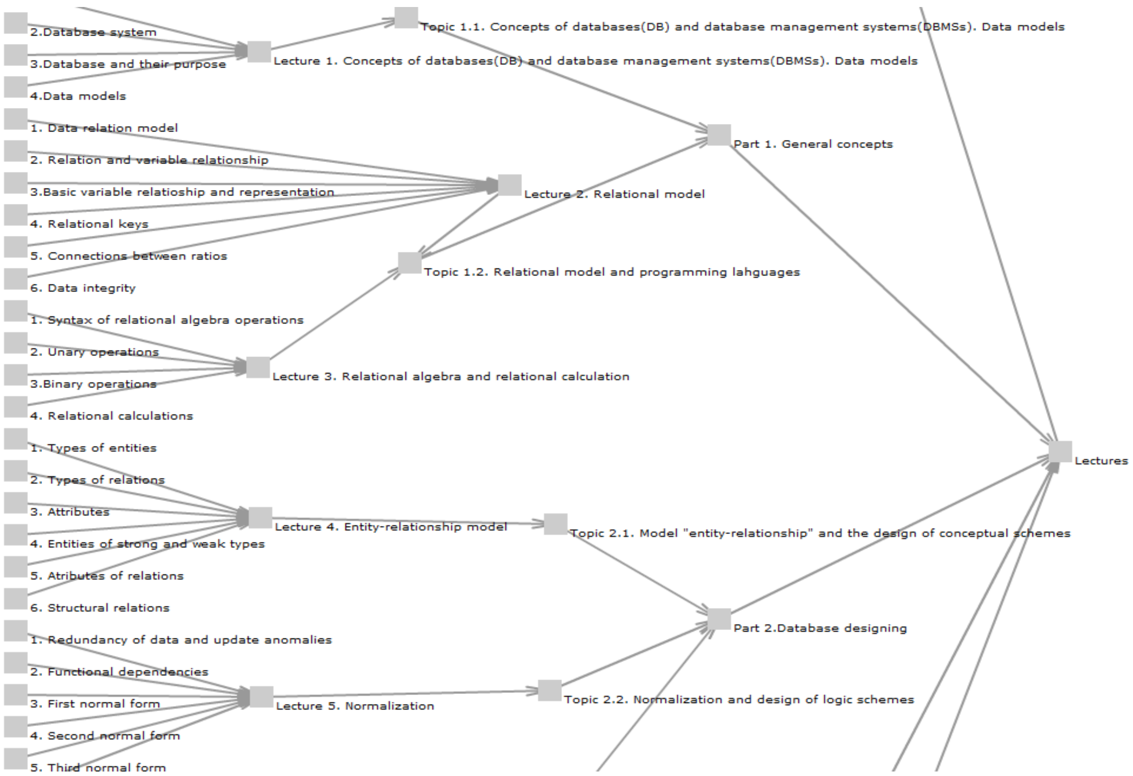

Figure 5b. Fragment of ontology to develop the credit module on discipline SOFTWARE OF DATA BASES (continued)

As one can see from the abovementioned example the whole educational standard and its course support could be represented in the form of aggregate of ontological models of the whole process of development of the bachelor's training course on the respective speciality. However, as one can see even from fragments of ontologies given in the respective Figures 1 - 5, we can make a conclusion that the axiom systems on each ontology and, moreover, functions of interpretation, do not match and may have not very robust overlapping. Thus, fragment of ontology SOFTWARE OF DATA BASES absorbs the whole axiomatics of ontograph SOFTWARE ENGINEERING. However the aggregates of interpretation functions of actions for each of the specified ontographs have both general and determined sets, which differ by semantics of elements.

To create the operational environment of ontological simulation of educational standards it is necessary to integrate the received models of component processes. Functional links between elements of aggregates, which determine notions-concepts, describe the certain procedures of process related to the patient's requests processing on problems of his/her health. Thus, we receive an aggregate, the elements of which are ontologies, which describe semantics of consultancy processes. The received aggregate of ontologies is determined as a single ontological model of interaction of processes related to resolving of consultancy tasks. Ontologies are combined and determined as a single ontological model of description of educational standard.

The separate formalized ontological models, which allowed to determining functions of interpretation of various levels of NFS, are based on an aggregate of functions of interpretation being specified on notions-concepts and their links.

Conclusion

Practical usage of ontological simulation requires application of various functions of interpretation. For instance, in our case the functions of determination of aggregate overlapping and analysis of matching are applied. Based on that it is necessary to apply the following procedure of integration of ontological models relates to processes of development and representation of various NFS levels that is designed on the basis of the following statement: aggregate of functions of interpretation of integrated ontology is not a combination of aggregates of functions of interpretations and ontologies of components, i.e., those which will combine.

Thus, ontological simulation of processes related to development of educational standards allows to optimizing a description of all HFS levels, determining a sufficient completeness of information content of subject courses, establishing correspondence between the systems of subject knowledge and competences, which should be developed among he graduates.

Additionally, the ontological models, due to their subject coherence, ensure correctness of development of inter-disciplinary links. It allows to optimizing the process of development of educational programmes, curricula and credit modules. Ontological models allow also to including into the curriculum the new technological solutions, knowledge of which is required for skillful specialist.

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Major Fields of Scientific Research: Means for Knowledge Management, Transdisciplinary Ontology, Network Instruments, Transdisciplinary Integration of Knowledge Networks, Information Systems for Educational and Research Activities, Aggregation of Distributed Information Resources