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THE USE OF ONTOLOGICAL MODELING IN THE PREPARATION OF ELECTRONIC COURSES IN THE FIELD OF INFORMATION AND COMMUNICATION TECHNOLOGIES

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ABSTRACT

The methodological foundations of designing electronic courses in the field of information and communication technologies (ICT) based on the ontological model are outlined. This kind of modeling makes it possible to implement automated processing of ontologies for an electronic ICT textbook. A functional and informational model of the processes that form an ensemble of information technologies for automated processing of ontologies of subject areas characteristic of the field of information and communication technologies has been implemented.

Keywords: *E-Courses, E-Textbooks, Ontologies, Subject Area, UML, IDEF, DFD, Composite, Pгoxy.*

1. INTRODUCTION

Intelligent information technologies influence the processes in economic, scientific and technical, humanitarian and educational and other fields of activity. Informatization or digitalization of the world society is focused on building an IT-oriented society. Knowledge engineering technologies are gaining weight. As an example of knowledge engineering, ontological engineering can also be mentioned. Modern IT uses knowledge management. We can say that progress in this direction is determined by the level of efficiency of computer systems [1–5]. As shown in the mentioned works, scientific research is being intensified on the creation of information systems built on knowledge bases (hereinafter referred to as KB), the development of methods for ontological analysis of subject areas (hereinafter referred to as SBA) to extract aspects of the application of ontologies from them. The latter is of interest, for example, in the context of the development of electronic training courses (EC) and electronic textbooks (ET).

Ontology can be used in many ways. For example, in order to describe the semantics of the e-learning process. Or to structure the stages of learning and communication tools, define the context of the ET. Only using the basic system of categories, we can give the basis for a clear construction of an ontological model of reality at the level that is reflected in modern science. That is, in fact, it is possible to build an adequate electronic textbook for a particular discipline.

Ontology as a conceptual system underlies any specific knowledge bases.

The relevance of new research in this area is due to such factors [6].

Firstly, most of the knowledge accumulated in the course of the civilizational development of mankind is contained in documents presented in text form. The growth of new textual information (especially on the Internet) has led to the fact that it has become almost impossible to completely process textual sources of knowledge, as well as to obtain relevant EC using methods existing in computer systems. This leads to the loss of part of the information and to the loss of relevance of the EC.

Secondly, often even modern PCs do not have sufficient performance to quickly complete the processing of text information for ECs and / or ETs. This is especially true for EC for new disciplines, for example, those related to the development of ICT. This is due to the fact that ICT is developing at a faster pace today. And EC and / or ET even a year ago, not to mention older electronic publications, do not always adequately reflect the necessary (required) level of competencies that students must master.

At the current stage of IT development, it has become possible to bring the existing theoretical foundations of artificial intelligence systems closer to the actual implementation, while taking into account the latest achievements in general engineering practice and subsequent promising trends in the development of computer technology in the preparation of relevant content of electronic courses in the field of ICT.

Note that the computerization of the educational process already at the level of secondary school or even primary school, according to many authors [1-3], is a large-scale innovation in the field of education. It is impossible to imagine teaching in a modern school if the teacher does not use a variety of computer technologies and the Internet in his educational work. This is especially true for disciplines where content is updated rapidly, in particular, disciplines related to the field of ICT. As shown in [6], visual-figurative components of thinking occupy a predominant place in the worldview of modern schoolchildren who have many gadgets, from smartphones to high-performance PCs or laptops. Which, accordingly, encourages teachers to present educational material in a visual expressive form, using a variety of color palettes, animation elements, dynamic illustrations, so characteristic of many modern ECs and / or ETs.

The study of the ICT course should introduce students to the methods for the most effective use of informatization tools in everyday practice. The examples given in the process of teaching students should clearly demonstrate that ICT tools can increase efficiency in the study of most disciplines that are read within the framework of high school and beyond colleges or universities.

The problem is that in the process of an adequate description of the interdependencies and interaction of the complex structures of a specific subject area (SbA), there is a possibility of terminological confusion complexity. So, for example, when speaking about the SbA of information and communication technologies, we should remember the high dynamism of their development. And if you tell students about the features of, for example, the 4G protocol, then this information will most likely be outdated in some 3-5 years. Not to mention older protocols like 2G or 3G. The mention and knowledge of which is more valuable in a historical context than refers to knowledge that is not relevant today.

Given the above, we can state that the relevance of new research in this area is justified by the need to develop effective methods of architectural and structural organization and the synthesis of relevant content for EC and ET in the field of ICT, especially for secondary school students. Such methods, in our opinion, enable all interested parties, from teachers in schools and colleges to commercial structures offering their EC and / or ET on the educational services market, not only to design relevant EC and / or ET with the processing of subject knowledge, but also to digitalize the process of their synthesis based on the processing of colossal volumes of textual information of subject disciplines inherent to the content of the ICT field.

2. REVIEW OF PREVIOUS STUDIES

As shown by a number of authors [6, 7, 8], the design methodology for EC and/or ET based on the method of computer ontologies (CO or MLO) requires the creation of an appropriate application system (toolkit). Object-oriented technology has become the main one in the development of such software (hereinafter referred to as SW). The authors of [9, 10] show that the development of any application system begins with an analysis of the requirements that it will satisfy. In the process of this analysis, the purpose and operating conditions of the system are determined,

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and its initial design is also developed. With an object-oriented approach (OOA) to a system, as shown in [6, 11], first, as a rule, a model of this system is developed. This can be done on the basis of the UML language, which allows to specify, visualize, design and document the artifacts of the systems of the corresponding software, for example, EC.

It is impossible to develop any system without subsystem objects that provide normative reference information, for example, a directory, lists, classifiers. UML terminology uses the term *Reference*.

The works [12–15] show that when implementing the subsystem of reference information using OOA tools, references can be divided into four types depending on their practical application: simple, subordinate, hierarchical, hierarchical subordinate. In the ontological model, reference of any kind can be used. Simple references include a reference in which only two details are mandatory: 1) the name of the element; 2) unique identifier of the reference element. Of course, a reference of this type is presented to the user as a set of elements designed at the user interface level in the form of a regular table. The subordinate references include references that, in conventional design, form a "master-subordinate" relationship with an element of another reference. To implement the presentation of such references, it is sufficient to have the following mandatory attributes - a unique identifier of the reference element, the father identifier, which provides access to the value of the parent element for the selected element of the subordinate reference, and the name of the element. In accordance with [12–15], hierarchical references allow their elements to be ordered in a freeway determined by the user of the system. To ensure the functionality of such a reference, it is necessary to have four mandatory attributes: a unique identifier of the reference element, a father identifier that provides access to the value of the parent group of the selected reference element, the name of the element, and a property responsible for whether the element is a group. The fundamental difference between hierarchical references and subordinate references is that for subordinates the nesting level is no more than two, and for a hierarchical reference it is not limited by anything. The last of the above types of references - a hierarchical subordinate, rarely has a practical application, for its implementation it requires the programming language to support the mechanism of multiple inheritance, therefore, in this work it is not considered.

The ontological approach in e-learning (EL) is being explored at universities around the world. A semantic similarity assessment tool is known that uses the "Palmer algorithm" and ontology [16]. The toolkit is still under development.

A number of authors are working on "onto-relational" learning. With this method, we are dealing with incomplete knowledge, one of the applications of which in learning tasks is the "Semantic Web" direction [17]. The toolkit for this system is under development.

Many studies devoted to improving the ontology design methodology are devoted to studying the possibilities of automating the stage of analyzing the subject area of the course [18, 19, 20]. In particular, the "pattern approach" is based on this. This approach involves an automated analysis of the subject area structures of an e-course, for example, an ICT course. This approach can assist the developers of electronic textbooks in many semantic tasks of ontology design. For example, it helps to coordinate concepts, etc. Unfortunately, the toolkit of this approach has not yet been brought to real use.

In [21], it was proposed to use "concept maps" to train the system that forms ontologies. This approach, from the point of view of visualizing the process of ontology formation, is the most illustrative. However, from in some cases leads to a weakly structured relationship between the elements of the map.

In [22, 23], a learning approach is proposed that is able to generate semantically related collections. The learning process includes the collection of documents with a semantic connection of concepts. The authors used the semantic storage of WordNet. To improve the efficiency of WordNet, an enriched ontology was built with the search for information from Wikipedia. However, we note that the information posted on Wikipedia is not always reliable.

In [24], an ontology of the MOOCs course domain was used, which offers free access to student materials. The disadvantage of MOOCs is the large number of forums. As a result, a significant flow of comments, questions (transactions) is generated [25, 26]. Accordingly, the problem how to provide feedback to listeners arises [27].

Since e-learning, electronic courses and electronic textbooks are currently poorly supported methodologically, normatively and technologically, courses and electronic textbooks are often subjective. In addition, in many schools, colleges, universities there is no single knowledge space, ontological knowledge bases for specific courses, for example, ICT, have not been fully developed. In addition, there are no tools for preparing EC and ET on ICT for schoolchildren.

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Numerous publications [7, 9, 14, 16, 17-27] and polemical issues overwritten in these works show that there is a need to develop a concept and methodology for constructing ontology-driven electronic textbooks. This will automate the development of ET in order to reduce human and time resources for this work.

3. METHODS AND MODELS USED FOR ONTOLOGICAL MODELING OF THE ELECTRONIC TEXTBOOK IN INFORMATION AND COMMUNICATION TECHNOLOGIES

It is necessary to develop a methodology for designing, implementing information technology (IT) for automated construction of EC and/or ET based on computer ontologies (CO) of subject areas. Also, the specified methodology process contains procedures for the synthesis of information and functional models of processes, which are based on the general theoretical basis for designing EC and/or ET with the processing of subject-oriented knowledge based on CO.

In general terms, the model of the projected IT, which consists of a number of processes, and aimed at solving the problem of automated construction of EC and / or ET based on ontologies in arbitrary SBA, can be represented as follows [6, 28]:

$$S = \langle P, A, X \rangle, \quad (1)$$

where:

corresponding sets

$P = \{p_i\},\ i = \overline{(1, n)} -$ processes that implement IT related to the construction of EC and / or ET;

$A = \{A_j\},\ j = \overline{(1, m)},\quad m \geq n -$ algorithms that implement multiple IT processes;

$X -$ entities that describe the SBA.

Conceptually, the diagram of the model is shown in Figure 1.

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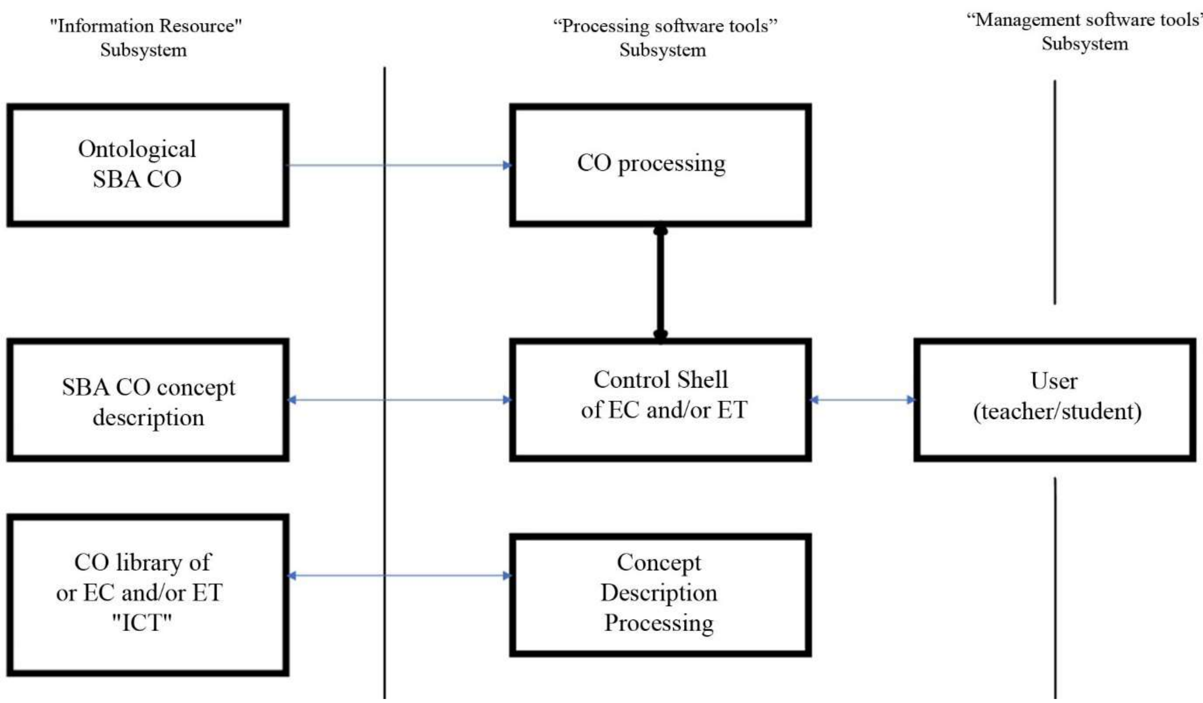

Fig. 1. Diagram of the model

The model includes three subsystems shown in Figure 1. Formally, this model in the diagram visualizes the cooperation of information resources based on CO, software for processing CO and software designed to solve problems related to managing processes that interact with each other. These processes actually implement a set of algorithms for automated preparation of ECs and or ETs. Let us consider subsystems in more detail.

When developing EC and / or ET, for example, in ICT, the more complex, in terms of methodology, and the more important part is the design of the ontology of subject disciplines (SD). For automated construction of EC and/or ET for SD ICT, it is

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necessary to use a formalized methodology for designing a SD ontology. In addition, you can use specialized software, such as Protege. The initial information for the automated construction of the SD ontology will be the existing EC and/or ET for specific SD.

In order to build an ontology, we sequentially define such finite sets [6, 28]:

$X = \{ x_1, x_2, \ldots, x_i, \ldots, x_I \}$ - concepts of SD;

$$R = \{ r_1, r_2, \ldots, r_\kappa, \ldots, r_K \}, R: x_1 \times x_2 \times \ldots \times x_I, k = \overline{1, K}, K = Card\ R$$

semantically significant relationships between the concepts of SD;

$$F: X \times R = \{ f_h \} : \{ x_i \} \times \{ r_k \}, h = \overline{1, H}, H = Card\ F$$

- interpretation functions that are given on the concepts and / or relations of SD.

The functional model for designing EC and/or ET based on CO is implemented with the help of UML. There are used 3 types of diagrams:

Use Case Diagram (Figure 2).

Activity Diagram (Fig. 3).

Class Diagram (Fig. 4).

The use case diagram defines:

1. General boundaries of SBA, for example, in the implementation of EC and / or ET in the ICT discipline.

2. General requirements for the functional behavior of the designed system.

3. Initial system model.

Diagrams are represented as a set of entities (actors). Entities interact with the system using appropriate use cases, as shown in Figure 2. An actor can be any entity that will interact with the system (for example, EC) from the outside. That is, actors can be people, technical devices, software, or any external systems. So, the latter can act as a source of influence on the simulated system. The use case describes the services provided to the actor by the system.

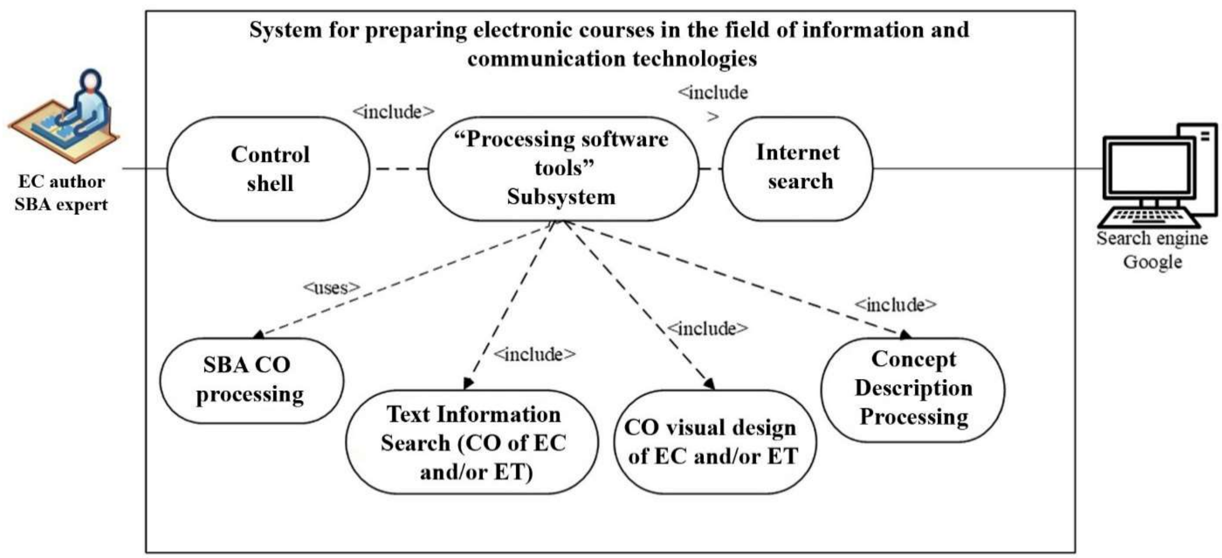

Fig. 2. An example of a UML Use Case Diagram for ECs and / or ET

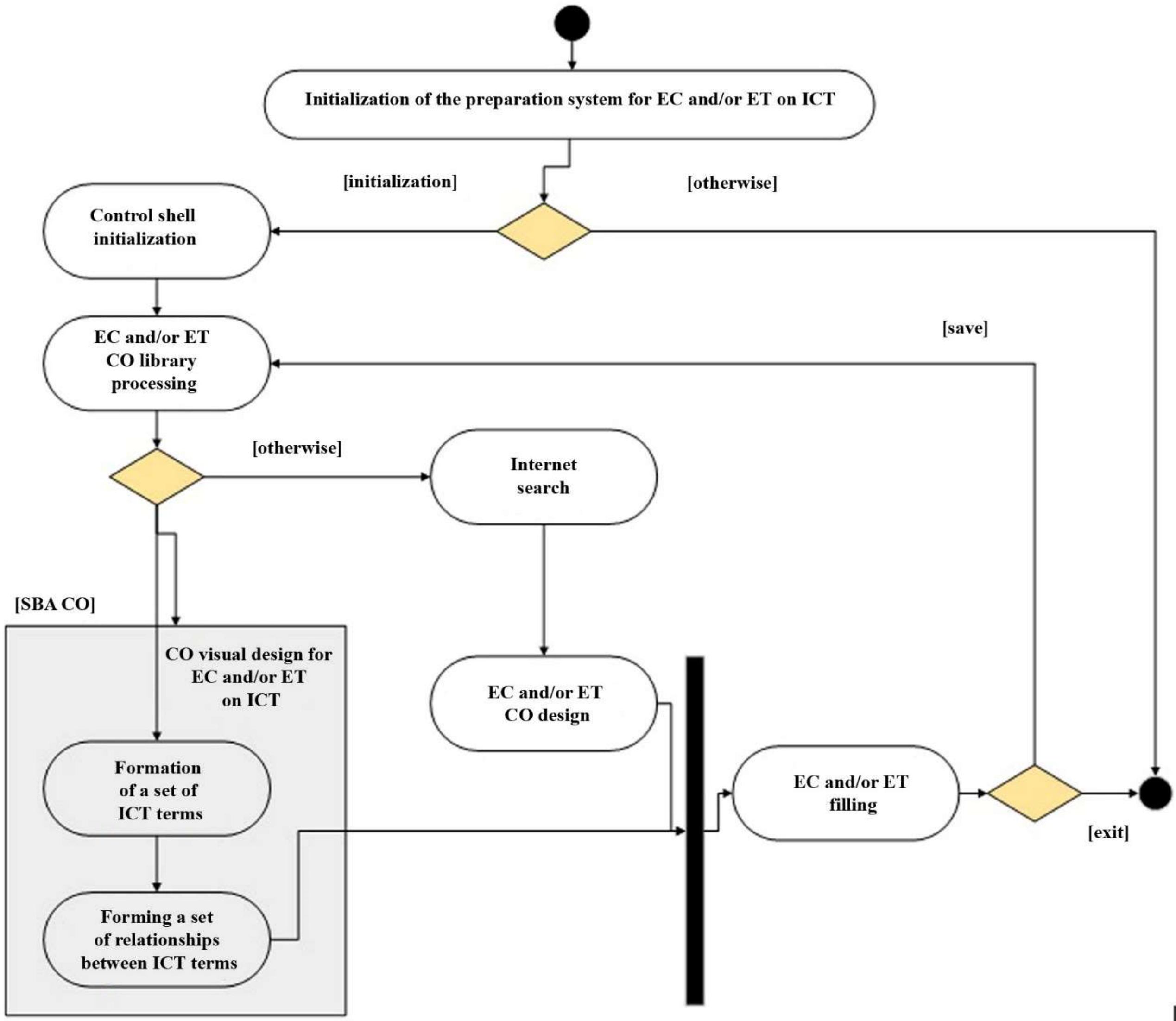

Fig. 3. An example of a UML Activity Diagram for ECs and / or ET

The activity diagram shown in Figure 3 visualizes the behavior of the system using the notations: data flow and control flow. The activity diagram reflects the algorithm. However, it differs from the classical block diagram. A block diagram usually describes only the steps of a specific algorithm. The activity diagram has a broader meaning [6, 28, 29]. For example, on the Activity Diagram, you can indicate the states of objects.

The Class Diagram is able to describe the structure of objects, while characterizing their presence: individuality; attributes; functions; procedures; and finally, the possibilities for relationships with other objects.

The Figure 4 shows a fragment of the UML Class Diagram, namely the following classes:

Search - performs processing of the CO library;

Ontograph - performs visual design of CO of EC and/or ET;

Control - implements the control shell of the EC and/or ET.

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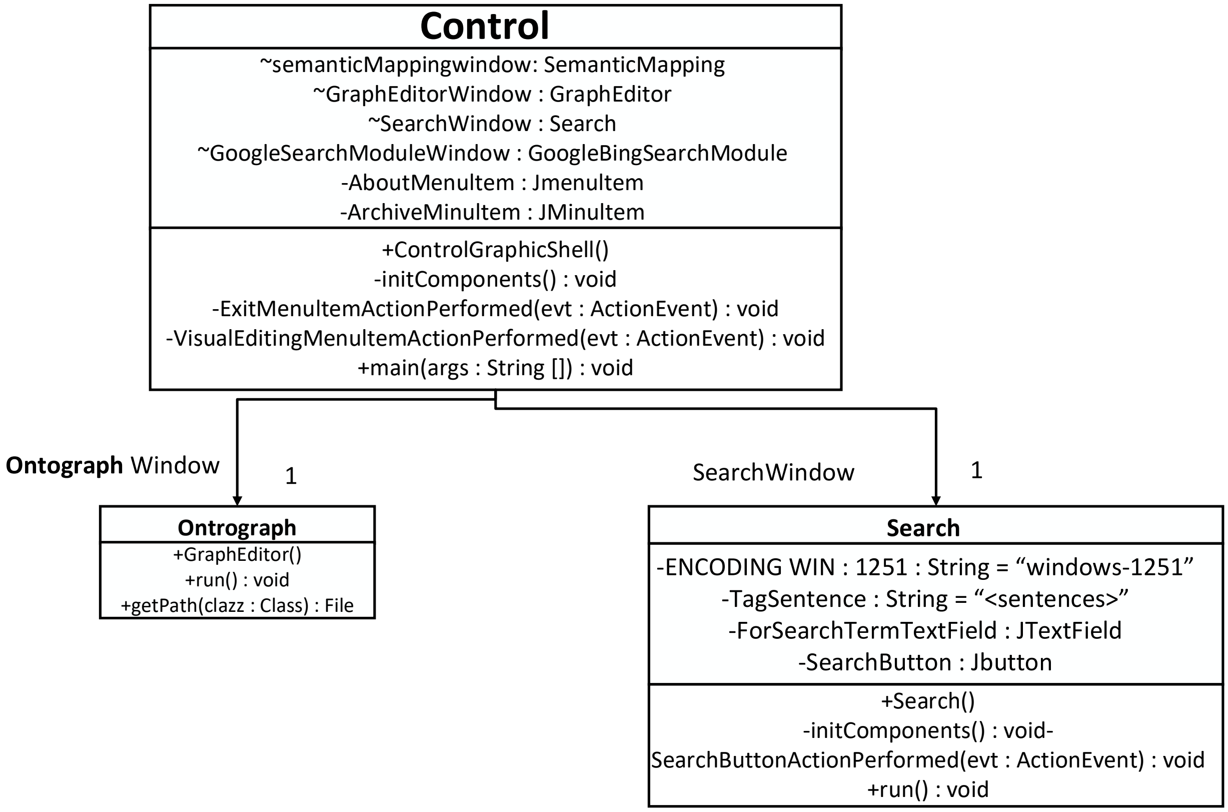
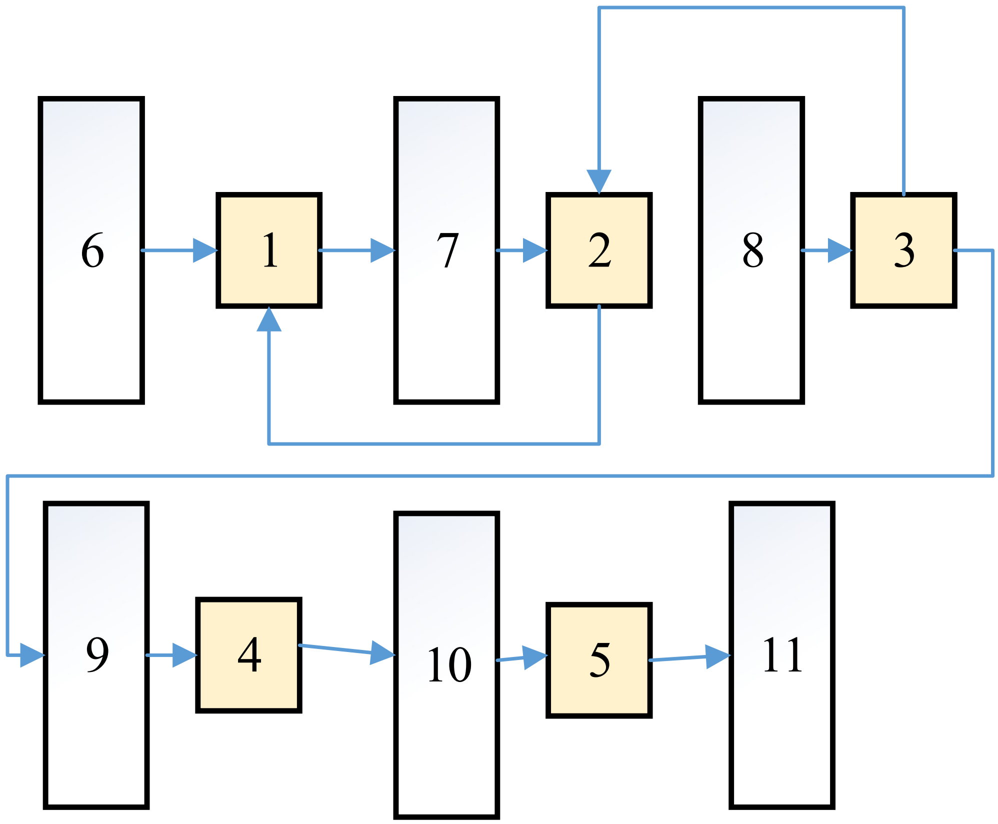


Fig. 4. A fragment of a UML diagram of classes specific to EC and/or ET

Figure 5 shows the scheme of IT preparation of EC and / or ET. In other words, this IT can be described as an informational component of the ontological model of EC and/or ET.

The “Information Resource” subsystem integrates blocks of text corpus, knowledge bases (KB) based on CO and libraries of SBA CO modified for specific EC and/or ET. In this case, a priori, credits, skills, abilities (competences) required from students should be taken into account.



The figure indicates: 1 - search for SBA CO in the "Information resource" subsystem; 2 - search for SBA CO on the Internet; 3 – extracting from the set of concepts of the SBA ontology those that are needed for EC; 4 – adjustment of CO links; 5 – extracting descriptions of ontology concepts and compiling EC and/or ET; 6 – ontological SBA KB (SBA CO); 7 - SBA CO on the Internet; 8 - corpus of texts describing the concepts of the SBA CO; 9 – set of concepts of EC ontology; 10 – set of descriptions of EC ontology concepts; 11 – library of COs of various ECs and/or ETs. (Yellow fill in squares, corresponds to search, adjustment and extraction operations. Rectangles are EC and/or ET components).

Fig. 5 Information component of the ontological model.

The first component is a KB of subject areas based on SBA ontologies (from sets of terms and concepts to a highly unified ontological structure of SBA).

The second component is a set of various sources of textual information. This component will be formed in the process of building the SBA ontology and is an analogue of an electronic collection of explanatory dictionaries.

The third component is a set of conceptual structures selected (from the general SBA ontology) for specific ECs, in our case, for an ICT course designed for secondary school students.

The “Processing software” subsystem combines blocks designed for processing text and conceptual structures. Also, this subsystem includes a control shell, which, in cooperation with the subsystem “Control software”, implements the preparation and execution of the relevant procedures when designing an EC and / or ET.

Let's select only service details, that are necessary to implement the functionality of these classes as references. When implementing the mechanism for using references by means of an object approach, it is necessary to design an appropriate class structure, the inheritance diagram of which is shown in Fig. 6.

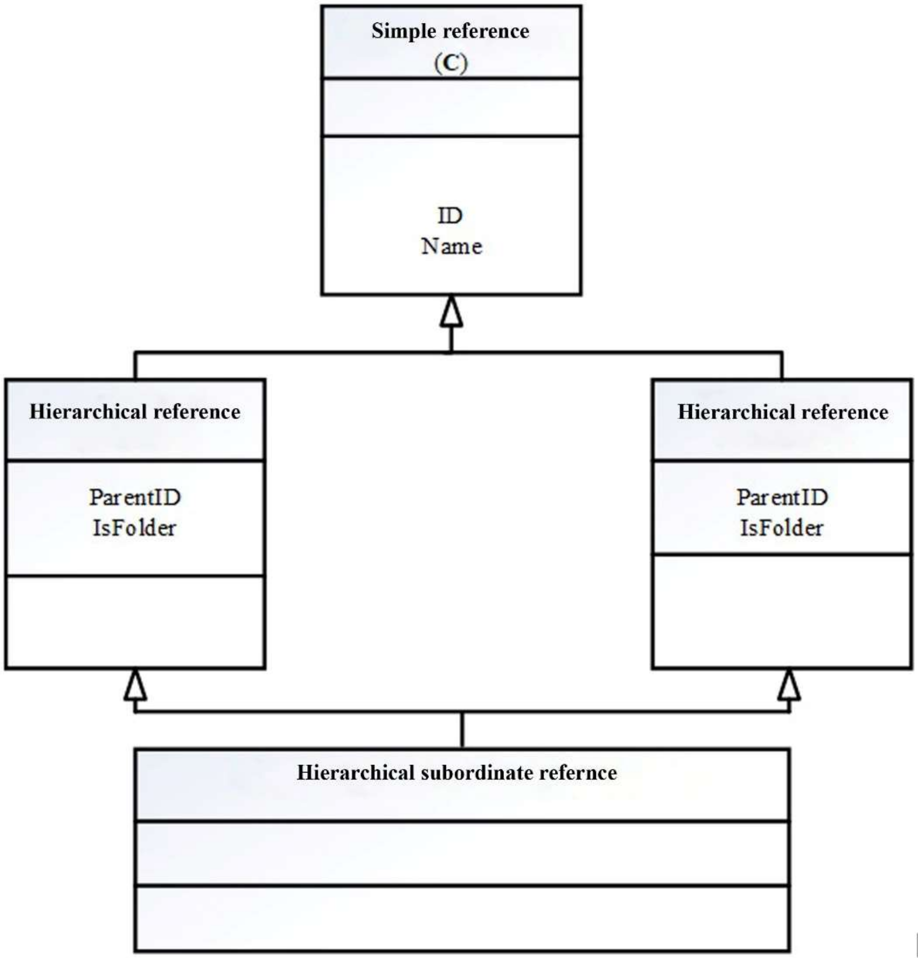


Fig. 6. Structural diagram of inheritance

The references used the Composite and Proxy templates [6, 12, 16]. The reference class defines the corresponding operations for displaying the contents of a EC and/or ET. The work with the data of the reference and its elements (operations responsible for searching for an element in the reference) is provided. There are at least three such methods: search by name, search by unique identifier, selection of a reference element. In the hierarchical and subordinate references, operations are required that can be used to determine the owner element for the selected reference element.

The processing of SBA ontologies and the implementation of reference information using the Composite template (linker) made it possible to obtain the results presented below during the research process.

4. RESULTS OBTAINED DURING THE RESEARCH

The methodology for the automated construction of ontology-driven electronic textbooks (ET) assumes at the first stage the development by the teacher in an automated mode of a complete ontograph of the ET. This can be implemented on the basis of existing textbooks or EC for this SD. Note that the ontograph is the first component of an ontology. The second element will be its formalized description. To do this, one of the generally accepted languages for describing ontologies can be used.

Let us show, using a simple example, how the formalization of the ontograph description will take place using the example of the topic "Databases", which is part of the ICT discipline, see Table. 1. Table 1 uses such designations as “Information and communication technologies” (ICT), “Formal logic”

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(ForLog), "Computing system" (ComSys), "Relational database" (RDB), "Relational data model" (RDM), "Database management system" (DBMS), "Predicate calculus" (CalPr), "Basic DBMS functions" (DBMS BF), "SQL language" "Methodological support" (DBMS MS) "Transaction serialization methods" (TSMet), "Index Organization Methods" (IOMet), "Journal Methods" (JMet), etc. The icon (→) in the last column of the table indicates that there is a connection with a concept that is not shown in Table 1, but is related to ICT SD. The logical connections presented in this form will be used later for the computer description of the ontograph. A sign (–) indicates no connection.

The ontograph of a typical ontology is characterized by the presence of many branches. There are also concepts of strict hierarchy of model representation.

Table 1
The matrix of logical connections of the ontograph (fragment)

№	Disciplines	1	2	3	4	5	6	7	8	9	10	…
		ICT	ForLog	ComSys	RDB	RDM	DBMS	CalPr	DBMS BF	SQL	DBMS MS	…
1	ICT	–	–	1	1	–	–	–	–	–	–	…
2	ForLog	–	–	–	–	–	–	1	–	–	–	…
3	ComSys	–	–	–	–	–	–		–	–	–	…
4	RDB	–	–	–	–	1	1	–	1	1	1	→
5	RDM	–	–	–	1	–	–	–	–	–	–	…
6	DBMS	–	–	–	–	–	–	–	1	1	1	…
7	CalPr	–	–	–	–	–	–	–	–	–	–	…
8	DBMS BF	–	–	–	–	–	–	–	–	–	–	→
9	SQL	–	–	–	–	–	–	–	–	–	1	→
10	DBMS MS	–	–	–	–	–	–	–	–	–	–	…
11	TSMet	–	–	–	–	–	–	–	–	–	–	…
12	IOMet	–	–	–	–	–	–	–	–	–	–	→
13	JMet	–	–	–	–	–	–	–	–	–	–	→
11	…	…	…	…	…	…	…	…	…	…	…	…

If the reference works with arrays of its elements, then the elements work with an array of their attributes. Therefore, the element will have operations that are associated with inserting, changing, deleting the corresponding details. When working with references, it is convenient to consider its totality, which forms an integral object of the EC and/or ET system. At the same time, distinctions are made between the concepts: a set of reference elements and a direct element. When designing references, for example, for EC and / or ET. This will provide a design template - Composite (linker). This template structures objects. It arranges objects in the form of tree structures. This makes it possible to display hierarchies in the form of a "part-whole" system and, accordingly, will allow to interpret individual and composite objects in a uniform way. When designing references for ECs and/or ETs using this template, you should initially select classes of primitives that act as containers of primitives. Small objects should be grouped into larger ones. This uses recursive composition. This makes it possible not to focus on the discrepancies between simple and composed objects. The key to the Composite type template is the abstract class. Such a class simultaneously represents both primitives and containers (Reference). It can declare operations that are specific to each type of reference and common to all compiled objects. To implement this template, define:

1. Referens – reference that performs such functions.

Communicates:

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interface for objects;

interface for accessing and managing descendants;

interface for accessing the father in recursive structures and implements it if necessary;

Presents:

a necessary operation that is common to all objects;

2. Item – element that:

will determine the behavior of primitive objects in the composition of EC and/or ET;

will present the leaf nodes of the EC and/or ET composition;

3. Composite – composite object that will implement such functions:

determine the behavior of the reference as a whole;

store descendant components (in our case, the elements of the ICT reference);

implement operations in the interface of the Reference class that relate to the management of descendants;

4. Client – client that will implement such functions:

manage EC and/or ET composition objects through the Reference interface.

In a slightly simplified form, the structure described above can be represented as follows, see Fig. 7.

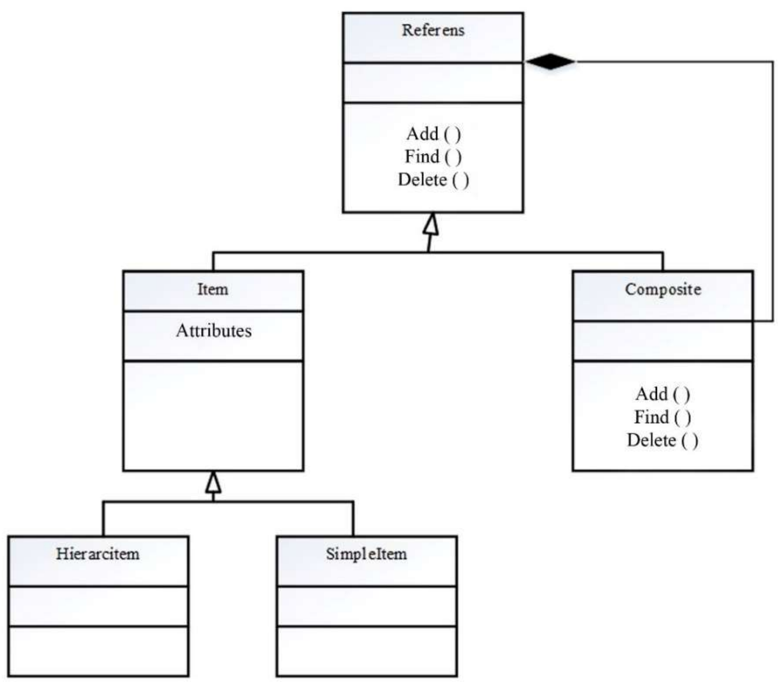

Figure 7. Composite template inheritance diagram

As a result of involvement in the development process of EC and/or ET, for example, on ICT (topic "Databases"), see Fig. 8, and the corresponding design template can be distinguished: the definition of a hierarchy of classes that consist of primitive and composed objects.

Clients will be able to work uniformly with individual objects and with composed structures. The client does not know whether he is interacting with a primitive or a composite object. There is no need to write functions that fork depending on which class object they interact with. And, besides, the process of adding new types of references is facilitated. New subclasses of the Composite or Item classes will be able to automatically interact with existing structures and client code of the EC and/or ET.

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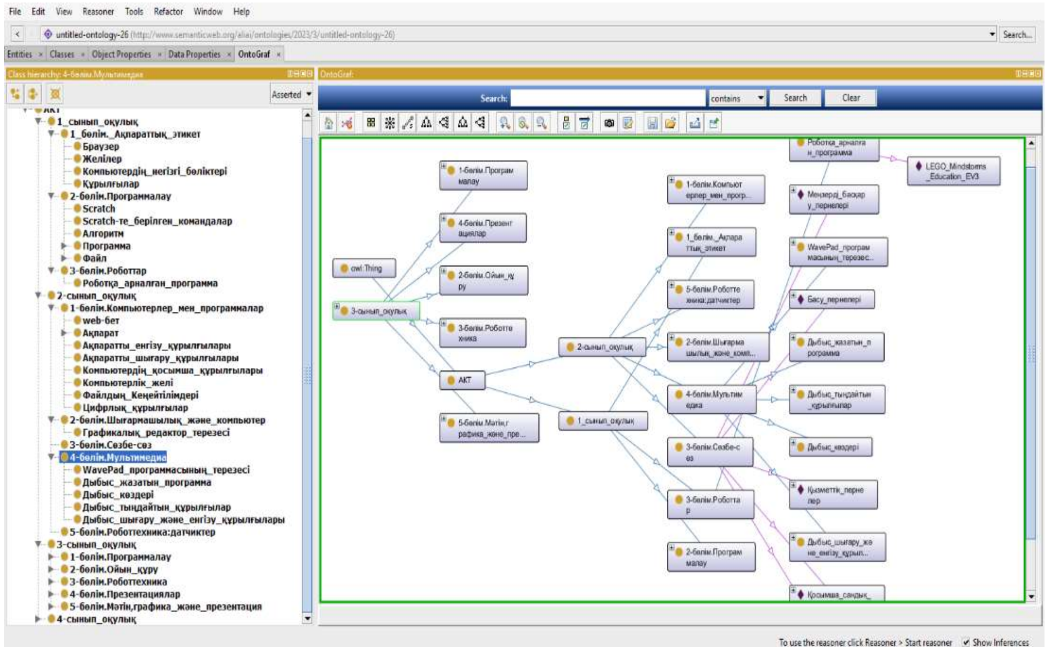

Fig 8. Composite template inheritance diagram for ICT ET

When implementing the linker template, you should take into account:

1. The presence of explicit references to the parents. The fact that keeping a link to your father in the reference makes it easier to bypass and manage the structure. It is proposed to define a link to the father in the Reference class when implementing EC and/or ET. The Item and Composite classes in this case inherit exactly the link and operations with it;

2. Maximization of the interface of the Reference class. Reference should perform the most operations that are common to the Composite and Item classes;

3. Grouping operations to manage descendants. The "Add" and "Remove" operations were implemented in the Reference class. These classes, respectively, can be used to add and remove descendants, for example, in case of a change in the content of a EC and/or ET. However, it is important for the template linker in which classes these operations are declared. If we specify an interface for managing descendants in the root class hierarchies, then we can achieve a certain transparency. However, this will reduce security because the client may try to perform nonsensical actions, such as adding or removing objects from leaf nodes. Note that if you implement the control of descendants as part of the Composite class, then it is possible to ensure data security in an EC and/or ET at an acceptable level. Nor do we lose transparency;

4. Caching to improve performance. The Composite class implements caching of information about tree traversal and related lookups. Caching allows to implement or have already received results. Any changes to a component must be accompanied by the generation of caches of all its parents. This approach will be most effective when the components know information about their parents;

5. Who has the ability and should remove components. An implementation has been made that gives the Composite class the ability to delete its descendants. The exception to this rule is when leaf objects are constant;

7. Which structure is best suited for storage.

In our case, it is established that the composed objects will be able to store their descendants in a wide variety of data structures. Such structures, which are typical for any EC and/or ET, include: linked lists, trees, arrays, and tabular cache structures.

When implementing the EC reference for the ICT discipline, this template was applied together with the Proxy template [12] (substitute), which structures objects and, in fact, is a “surrogate” of another object and controls access to it. In doing so, a number of issues were resolved:

– what should be placed instead of the reference object?

– how it is possible to ensure the processes of creating objects on demand;

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– how to make it so that the optimization is not reflected in the code regarding the implementation of the methods of the reference for the ICT disciplines.

A solution was found to use another object - the Proxy object ("reference substitute"). This object is temporarily presented instead of a real reference. The proxy behaves in the same way as the object itself. The "substitute reference" template is also advisable in cases where it will be necessary to refer to an object in a more diverse way.

5. DISCUSSION OF THE OBTAINED RESULTS

When developing EC and/or ET using a client-server architecture, the implementation of the proxy template for the reference finds a place both on the add-on server and on the client side. On the add-on server, you can implement loading on the mention of an object at the first call, blocking, access rights to EC and / or ET objects, counting the number of links to an object in order to load an object from memory. On the client side, at least it is also possible to implement loading on the mention of an object on the first call, as well as implement one more optimization. It is connected with copying the modified object. An object is only copied if it has actually been modified.

When designing a reference for ECs and/or ETs, it is reasonable to use the Composite and Proxy templates for processing SBA ontologies. With the help of the proxy, indirect access to the reference object is carried out and a link to another reference object is stored in its implementation. The proxy also provides the client with an interface that matches the interface of the reference object being replaced. The linker is engaged in the implementation of the reference at the physical level, that is, the implementation of the main methods. Proxy optimizes the operation of the reference object both at the client level and at the add-on server.

Thus, the use of Composite and Proxy templates is an integral part of the methodological foundations of designing EC and/or ET set forth in the work. The use of these templates will make it possible to automate the processing of SBA ontologies, in particular, for such as ICT. The results obtained are focused on improving the efficiency of the process of preparing electronic courses and / or electronic textbooks.

Currently, e-learning methods and technologies are rapidly developing in parallel with the World Wide Web. At the same time, methods and forms of learning are constantly being improved. The latter, in fact, are increasingly oriented towards the achievements of Internet technology. In connection with the COVID-19 pandemic, many countries have introduced new forms of distance learning based on computer and telecommunication technologies, including such forms as e-learning. At the same time, all kinds of EC and ET are also actively developing.

The advantages of our study include a decrease in subjectivity in the preparation of EC and / or ET. As well as a significant reduction in development costs. Currently created manually ET are subjectivized. Their creation requires a significant investment of time by highly skilled developers.

The proposed model, the corresponding concept and methodology are useful in that on their basis it is possible to proceed to the development of a tool for ontologized, automated design of ET, ready for widespread implementation. After that, it can be applied in any universities and schools.

6. CONCLUSIONS

As a result of the research carried out in the framework of this article, the following main results were obtained:

proposed a methodology for designing electronic courses (EC) and/or electronic textbooks (ET) in the field of information and communication technologies (ICT) based on the application of an ontological model;

shown that the ontological model proposed in the article is intended primarily for the implementation of information technology for automated processing of ontologies of ICT subject areas, which will simplify the procedures associated with the implementation of EC and / or ET, based on relevant content in the field of ICT that meets the current state of this subject area with the ability to update this content as needed;

a functional and informational model of processes has been implemented, which together will form an ensemble of information technologies for automated processing of ontologies of subject areas inherent in the field of ICT based on computer ontologies (CO);

an analysis of modeling technologies was carried out, namely, such technologies as IDEF, DFD, UML, which can be used in the design of complex systems, for example, EC and / or ET in the field of ICT for secondary school students;

UML-diagrams are given that describe the functional design model of EC in the field of ICT based on CO.

The results obtained are aimed at improving the efficiency of preparing electronic courses and / or electronic textbooks, primarily in the field of ICT for secondary school students. However, the results presented in the article can also be used to build EC and / or ET and for other subject areas, which are characterized by the highest level of formalization of knowledge description and the presence of CO of these subject-disciplinary areas.

It is shown that the ontological approach makes it possible to assemble a unified, well-structured and transparent system of lesson topics within the framework of both one subject discipline and the whole course, for example, when it comes to such a subject as ICT for secondary school students. Substantiated, the thesis that the ontological approach helps teachers to better navigate the construction of new and development of long-existing and time-tested courses, thereby allowing to ensure the implementation of the didactic principle of systematic and consistent learning.

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