The object of the research is the technology of constructing a computer ontology (CO) for electronic textbooks of the subject area (KSA). As an example, the industry is considered-information and communication technologies (ICT) and the topic "databases".

The subject of the study are models and methods of automated construction of a CO of the KSA.

The methodology of modification of CO in the field of ICT is proposed by introducing into the formal computer ontology a description of the technologies of the learning process for secondary schools or extracurricular institutions, as well as for professional retraining of specialists, which allows preserving and reusing the collective experience of learning in an educational institution.

The proposed solution differs from the existing ones in that the system of ontologized design of electronic courses (SODEC). It allows to automate the development of electronic courses (EC) and/or electronic textbooks (ET), reduces the cost and time of preparing ET, ensures compliance of EC with the current state in the field of ICT. As an example, the design section of ET for the topic "databases" is considered. The proposed solution allows to accumulate personal materials of the teacher and contributes to the rapid updating of the content and content of ET, if necessary. It is concluded that for more effective use of the proposed methodology, it is necessary to develop a similar SODEC, taking into account the language of description of CO – OWL, which will allow to accumulate collective experience in the methods of submitting material to teachers of educational institutions or extracurricular institutions, as well as during professional retraining of specialists

Keywords: computer ontology, electronic textbooks, ontology description language, genetic algorithm

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MODIFICATION OF THE ONTOLOGY USING THE TEACHER'S PERSONAL MATERIALS TO INCREASE THE DEGREE OF AUTOMATION OF EC PREPARATION

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1. Introduction

With the digitalization of modern society and the rapid development of information and communication technologies (ICT), which today are deeply integrated into almost all spheres of human activity, there has been a need to develop innovative methods and training tools at all levels of training. These methods and training tools should be focused on training specialists who will be able not only to process and analyze information materials, but also to effectively solve problems related to decision support in industrial design, classification of scientific and technical documentation, integration of information services of partner companies, etc. The beginnings of such competencies should be laid in high school, or in out-of-school institutions, for example, engineering and technical centers for youth, as well as during professional retraining of specialists.

According to a number of experts, the relevance of research in this direction is due to such factors [1].

Firstly, as in the general task of creating electronic courses and/or electronic textbooks (hereinafter let's use the abbreviation EC), part of the knowledge of the subject area (KSA) of ICT and its relevance may be lost due to the increase in new information in printed form. This is not least due to the rapid pace of ICT development that is taking place today. Modern schoolchildren should not only have knowledge in the field of ICT, but also in their subsequent activities become full-fledged specialists in their use.

Secondly, ECs KSA of ICT for high school or non-school institutions, as well as for professional retraining of specialists, have their own specifics. It is, in particular, about increasing the cognitive quality of EC, increasing the use of multimedia tools, interactive teaching methods, etc. Let's note that visual-figurative components are especially important in the worldview of schoolchildren, which encourages teachers to create EC in a visually expressive form, for example, by using multimedia.

Thirdly, the widespread use of personal computers (PCs) and other mobile gadgets (smartphones, tablets, laptops) in schools and in out-of-school institutions and professional retraining institutions. Moreover, in some cases, only PCs are not always suitable for the rapid processing of volumetric layers of material in individual ICT courses and disciplines. For example, when it comes to courses or topics "Mobile devices and networks", "Mobile Internet security", etc. This leads to a specific CO, characterized by the introduction of CO learning processes for a given KSA.

Fourthly, computerization of the educational process already at the secondary school level [2] is an innovation in education.

Let's note that computer educational networks (or simply CS), educational telecommunications provide students with the opportunity to access distributed databases (DBs), participate in teleconferences, communicate via email, instant messengers, etc. [3]. The use of CS for communication requires the information culture of the individual. The concept of computer literacy has been transformed into the concept of information culture. It is necessary to start building a person's information culture from school.

The above leads to even greater specificity of CO KSA of ICT for EC in schools, out-of-school institutions, professional retraining institutions.

Taking into account the above, it is possible to state that the relevance of research in this direction is justified by the need to modify CO by adding a description of the technological processes of training for EC in school, non-school institutions, and professional retraining institutions.

2. Literary analysis and statement of the problem.

The works [1] show that one of the most effective computer methods for representing knowledge is the CO. For example, the content of topics and sections of the subject discipline (SD) "Mathematics" is described with varying degrees of detail by several ontologies, in particular, the ontology of the ScienceWISE project [2], the ontology on natural sciences and technologies.

But issues related to the original teaching methods and techniques of individual teachers are still unresolved. The reasons for this may be the lack of tools for describing such techniques, the costly part in terms of the amount of work, which makes relevant research impractical. An option to overcome the corresponding difficulties may be modifications of CO in the field of ICT by introducing descriptions of learning process technologies into CO.

This is the approach used in [3], where an example of the hierarchy of ontology classes of an arbitrary educational course is given, as well as fragments of subject ontologies in the OWL language. However, there is no description toolkit, the amount of work to create an EC is large. All this suggests that it is advisable to conduct a study devoted to modifications of CO by introducing CO learning processes.

In [4] it is shown that the use of semantic technologies for EC modeling is one of the examples of the use of the ontological approach. The authors show that the potential of ontological modeling is determined by the features of using EC in the educational process. The EC ontological modeling technologies proposed by the authors are aimed at a specific applied result, to achieve which methods for creating ordered data structures are effectively used. However, the potential of computer ontologies is not used.

In [5] it is indicated that one of the most labor-intensive processes when creating an EC is the construction of a domain KO containing conceptual knowledge. Tools are also being developed for the automated construction of ontological knowledge bases. However, KO does not accumulate original methods and techniques for teaching teachers.

Paper [6] provides an overview of research on the use of semantic web technologies in education, including ontologies, and virtual learning environments. However, the above studies do not use all the capabilities of educational institutions to accumulate teaching methods and techniques.

The work [7] discusses the ontological approach to the formation of EC. The proposed approach is distinguished by the use of CO, but the use of teacher techniques is not automated.

The paper [8] explores the Ontological design, development in E-learning When Studying Information. However, studies do not use accumulate teaching methods.

The paper [9] explores ontology engineering with ontology design patterns, but the use of teacher techniques is not automated.

The paper [10] concerns the use of knowledge graphs, machine learning, natural language processing based on ontologies, but does not address the issues of accumulating teaching experience.

Local problems identified in the sources include:

– unresolved issues of preserving and further using teachers' experience in subject area ontologies [1, 2];

– lack of tools for describing teaching methods and techniques for EC in OWL [3];

– underutilization of the computer ontologies potential (as a method of creating ordered structures) in the educational process [4];

– omission of the opportunity to include teaching methods and techniques in the CO of the subject area when developing tools for the automated construction of ontological knowledge bases [5, 6];

– missing the opportunity to automate the use of teaching methods and techniques [7, 8, 10].

At the same time, one of the most labor-intensive processes when creating an EC remains the inclusion of methods of presenting material and personal materials of teachers.

The above allows to assert that it is advisable to conduct a study devoted to the modification of computer ontology by describing in it the methods of presenting material and personal materials of teachers.

3. The aim and objectives of the study

The aim of the study is to identify the influence of subject area ontology modification by describing the teacher's personal materials in it on increasing the degree of automation of the computer ontology preparation for EC. This will make it possible to integrate the experience of teachers into the knowledge base of an educational institution, save personal materials of teachers for EC in the knowledge base in the OWL language, involve more ECs in the educational process, and automate the inclusion of the teacher's personal materials in the EC.

To achieve the aim, the following objectives were set:

– to develop of the design process;

– to develop of a means of automated preparation of EC;

– to develop of CO design tool, including methodological techniques for training obtained from teacher's experience.

4. Materials and methods

The object of research in the work is a specific (ontological) representation of subject area knowledge for EC preparation.

The main hypothesis of the study is concluded in the fact that by adding the ontology of the subject area an ontological description of the teacher's personal materials to the description, the degree of automation of the EC construction will increase.

The study suggests that CO forms a dual approach to the use of EC:

– on the one hand, ontology is a representation of knowledge that builds EC at the conceptual level of knowledge, strictly structures information for EC, allows learning to be concentrated around the most significant concepts, and in this sense defines generally accepted, semantically significant "conceptual knowledge units" for EC;

– on the other hand, CO is a tool with the help of which it is possible to automate the EC preparation.

Simplifications taken in the work it is considered that all personal materials of the teacher define common, conceptual knowledge from the subject area.

Suggested methods, software:

– ontological description of the subject area;

– using ontology editors that allow to work with xml, rdf, owl, html formats, including a protégé editor;

– algorithmization of the EC construction process.

The adequacy of the proposed methods is determined by the fact that the ontology defines commonly used, semantically significant "conceptual knowledge units" for EC, provides a unified structure and reuse, increases the EC life cycle and the possibility of automated construction of EC at lower costs.

5. Results of research on the methodology of modification of computer ontologies of electronic courses on ICT

5. 1. Development of the design process. CO for ICT, including CO for learning processes

The development of the design process of EC for ICT is considered (using the example of the topic "database" – DB), including ontological descriptions of EC structures, testing of learned material, criteria for the need to repeat poorly learned material, taking into account the experience of teachers of an educational institution to increase the degree of automation of EC construction.

As an example, the topic "Relational Databases" is considered.

In its formal form, the model of the designed CO will look the same as the general model of the CO KSA (1) [1]:

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

where corresponding sets:

$P=\{p_i\}$, $i=(1, n)$ – processes for constructing EC and/or ET;

$A=\{A_j\}$, $j=(1, m)$, $m \geq n$ – algorithms that implement these processes;

X – entities (concepts) describing KSA.

In our case, the construction of CO is simplified due to the absence of the need for semantic machine analysis of concepts.

Protege was used for developing the subject area ontology. Initial information for constructing an ontology is available on the Internet, textbooks, manuals, etc. in informal natural language.

When constructing the CO, let's define the following finite sets [1]:

– subject area concepts:

$$X=\{x_1, x_2, \ldots x_i, x_I\};$$

– ontology processes for EC will be reduced to:

$$R=\{r_1, r_2, \ldots r_K\},\ R: x_1 \times x_2 \times \ldots \times x_I,$$

semantically significant relationships between KSA concepts.

Interpretation functions (algorithms), which are defined on concepts and relationships, are reduced to descriptions of concepts.

The situation with the ontology of teaching methods is more complicated. The sets of x and r for this case must be obtained from the teacher's experience. The set of algorithms that implement, for example, multimedia technologies, goes beyond the scope of ontological approaches [11].

Multimedia educational systems combine a lecture with demonstration of learning material, testing and additional materials. Multimedia objects significantly increase students' interest in the subject, accelerate learning and provide better knowledge acquisition [12].

However, the ontological approach in such systems is not taken into account; many operations for constructing an EC are done manually and the adequacy of the EC can only be ensured by the authority of the developer.

For example, SOPEC [8] is based on ontological knowledge, provides effective machine processing of the ontological description of knowledge and provides automated EC filling with the necessary (from the teacher's experience) elements of a methodical nature, including multimedia. However, these elements are not structured, not collected into an ontology, and there is no possibility to use them for other EC.

Fig. 1 shows a diagram of the EC and/or ET preparation, taking into account the CO of the learning processes.

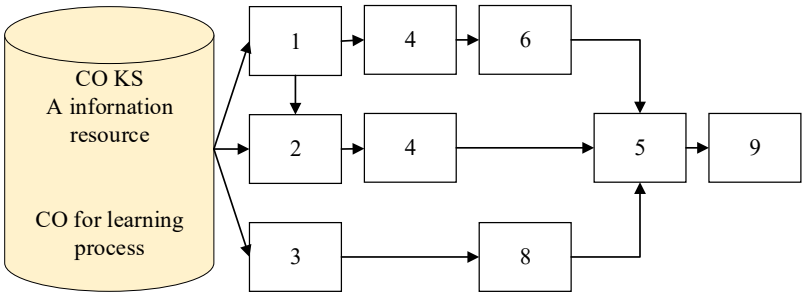

Fig. 1. Scheme for preparing EC and/or ET (using the example of ICT) (theme "Databases"): 1 – extraction of ontology concepts that are needed for EC; 2 – extracting descriptions of ontology concepts; 3 – extracting descriptions of methodological techniques of the teaching process obtained from teachers' experience; 4 – CO correction; 5 – EC and/or ET construction; 6 – set of concepts of EC ontology; 7 – set of descriptions of EC ontology concepts; 8 – descriptions of methodological techniques of the teaching process obtained from teachers' experience in a given subject area; 9 – library of computer ontologies of various subject areas

5. 2. Development of a means of automated preparation of EC

The development of an SBA CO database for a school is considering.

Concepts related to Fig. 3 are highlighted in Fig. 2.

In Fig. 3, the paths to the concepts corresponding to the highlighted concepts in Fig. 2 are highlighted. The corresponding fragment of the descriptions of the SBA CO DB concepts is presented in Table 1.

A complete description of the SBA CO DB concepts in printed form contains more than 200 pages and is the basis of the DB dictionary.

The CO DB from the "Information Resource" contains more than 1000 concepts, of which 200 were selected for the EC. The EC required multimedia objects that increase the cognition of the EC and are not included in the formal CO DB.

The corresponding fragment of the ontograph with multimedia objects (MO) of descriptions of CO DB concepts is presented in Fig. 4.

The corresponding fragment of multimedia objects descriptions is presented in Table 2.

The article proposes an application for automated selection of links from the table. For example, for the DB concept, the application displays a window providing to select one of the options (DB in a bank, DB in retail chains, department DB), after selecting, the link is inserted into the EC automatically.

```
<.....
        <rdfs:subClassOf rdf:resource=«#tookit»/>
        </owl:Class>
        <owl:Class rdf:ID=« design_system»>
        <rdfs:label rdf:datatype=«http://www.w3.org/2001/XMLSchema#string»
        > Executing queries</rdfs:label>
        <rdfs:subClassOf rdf:resource=«#tookit»/>
        </owl:Class>
          <owl:Class rdf:ID=« DBMS»>
          <rdfs:label rdf:datatype=«http://www.w3.org/2001/XMLSchema#string»
          > Executing queries</rdfs:label>
          <rdfs:subClassOf rdf:resource=«#tookit»/>
          </owl:Class>
          <owl:Class rdf:ID=« basic_means_of_manipulation»>
          <rdfs:label rdf:datatype=«http://www.w3.org/2001/XMLSchema#string»
          > Executing queries</rdfs:label>
          <rdfs:subClassOf rdf:resource=«#DBMS»/>
          </owl:Class>
          <owl:Class rdf:ID=« client_server_DBMS»>
          <rdfs:label rdf:datatype=«http://www.w3.org/2001/XMLSchema#string»
          > Executing queries</rdfs:label>
          <rdfs:subClassOf rdf:resource=«#DBMS»/>
          </owl:Class>
          <owl:Class rdf:ID=«local_DBMS »>
          <rdfs:label rdf:datatype=«http://www.w3.org/2001/XMLSchema#string»
          > Executing queries</rdfs:label>
          <rdfs:subClassOf rdf:resource=«#DBMS»/>
          </owl:Class>
            <owl:Class rdf:ID=« main_DBMS_functions»>
            <rdfs:label rdf:datatype=«http://www.w3.org/2001/XMLSchema#string»
            > Executing queries</rdfs:label>
            <rdfs:subClassOf rdf:resource=«#DBMS»/>
            </owl:Class>
</owl:Class>.....
```

Fig. 2. Fragment of the computer ontology of the database subject area in OWL format (Fig.1, block 6)

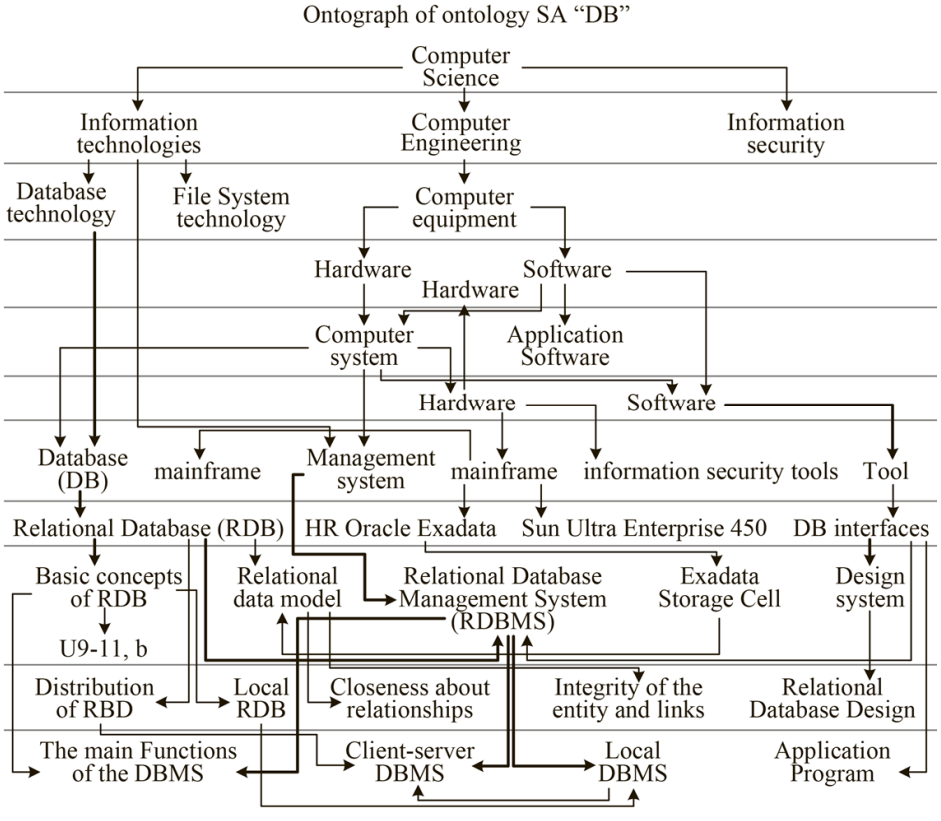

Fig. 3. A fragment of the ontograph is presented, corresponding to Fig. 2

Table 1

Fragment of descriptions of concepts of the SBA CO DB, corresponding to Fig. 3

Vertex (concept) name	Concept interpretation
DB management system	The existing traditional capabilities of existing file systems are not sufficient to build a full-fledged information system (IS). Here is a small list of IS functionality that is not covered by the capabilities of file systems: support for a logically consistent set of files; providing data manipulation languages; data recovery after various types of failures and emergency shutdowns of the IS; parallel work of several users. It is possible to assume that if an application IS is based on some data management system that has the properties listed above, then let's consider such a system a data management system or a database management system (DBMS)
Basic functions of the DBMS [1]	Direct data management in external memory. Managing RAM buffers. Transaction management. Loging. Database language support. The organization of the DBMS and the composition of its components corresponds to the set of functions [1]
Buffer management	DBMSs usually work with databases of impressive size; at least this size usually significantly exceeds the available amount of RAM. Consequently, if, when accessing any data element, an exchange with external memory is implemented, then the entire system will operate at the speed of the device

Table 2

Fragment of SBA CO DB concepts descriptions

Vertex (concept) name	Related multimedia objects	Related MO multimedia objects associated with MO of column 2	Links (the example file path is for a location)
BD	Animation "Using the database"	DB in a bank	D:\KOBD2021\OPIS\MO_KOBD\BD_BANK.avi
		DB in retail chains	D:\KOBD2021\OPIS\MO_KOBD\BD_TORG.mp4
		Department DB	D:\KOBD2021\OPIS\MO_KOBD\BD_VEDOMCTV.mp4
DBMS	Video of DB maintenance	DBMS for Department DB	D:\KOBD2021\OPIS\MO_KOBD\TO_BD.avi
	Video of action after hard failure	DBMS for Department DB	D:\KOBD2021\OPIS\MO_KOBD\BD_GEST_SBOY.avi
	Video of database normalization	DBMS for Department DB	D:\KOBD2021\OPIS\MO_KOBD\BD_NORM.mp4

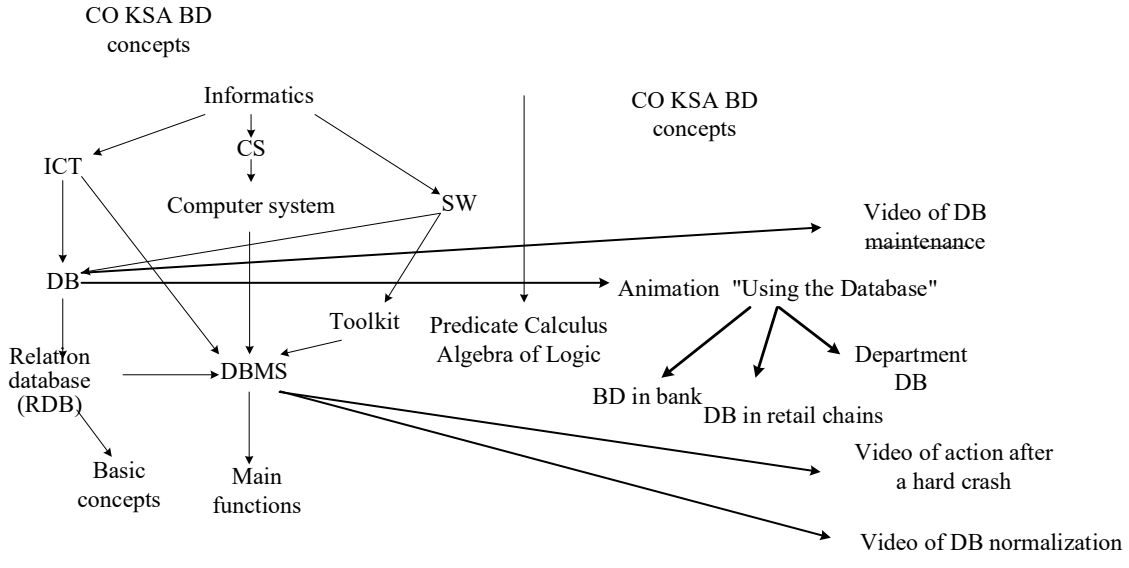

Fig. 4. Fragment of the CO "DB" ontograph with added multimedia objects

5. 3. Development of CO design tool, including methodological techniques for training obtained from teacher's experience

The conceptual framework is shown in Fig. 5 in the form of teacher's personal material base, (3).

In module 4 (SAPREC), the EC structure is filled in a graphical environment using the description of the SBA CO and multimedia objects not included in the EC.

Module 5 (EXPORT) provides automated replenishment of the EC with MO elements according to the teacher's decision, recording test questions, exercises, testing material, recommendations and examples of completing assignments, etc. into a file for the EC.

Module 6 (STAT) provides a set of statistics on the distribution of EC scores by the number of students who received a given score to assess the quality of the EC, saving statistics in the EC database.

Software and interface (Fig. 6, 7) is directed, including the construction of an ontology in both manual and automatic input of concepts.

In Fig. 6, a computer ontology has been selected for the "database system (dbms)" in owl format.

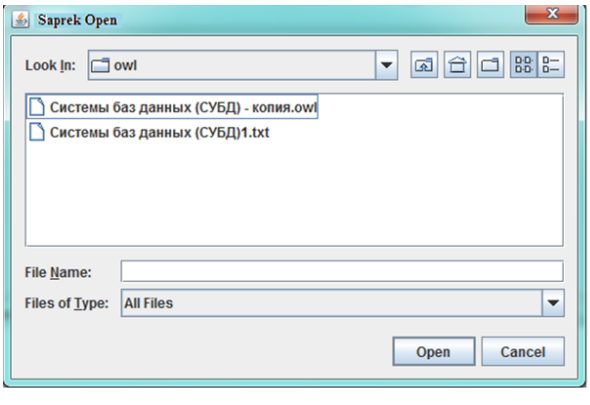

Fig. 6. Program interface for selection and automated modification of computer ontology and further EC construction

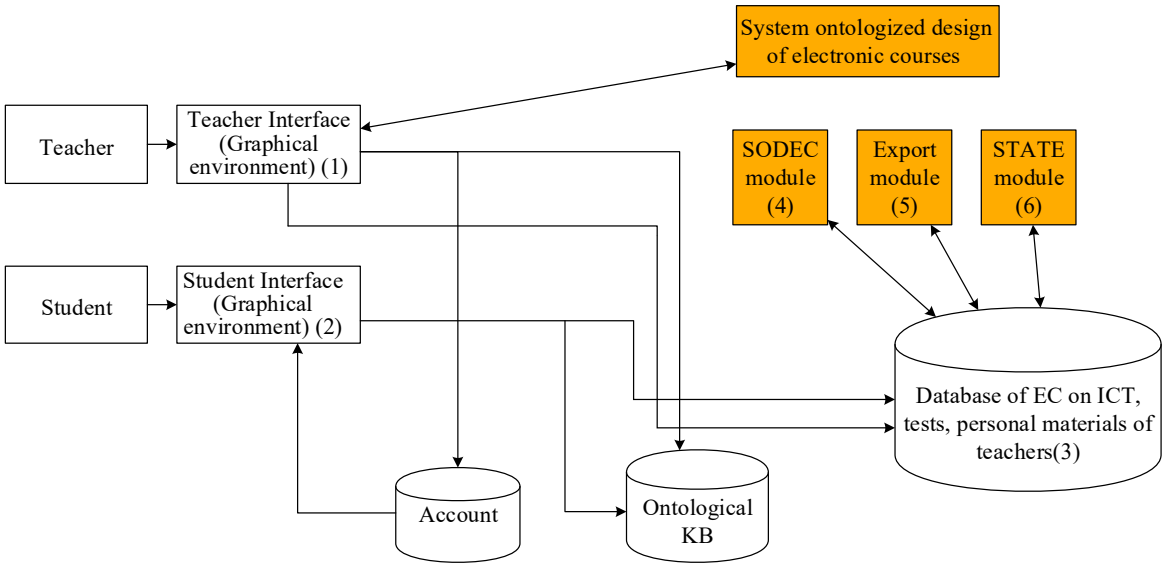

Fig. 5. Using the system of online design of ITC electronic courses

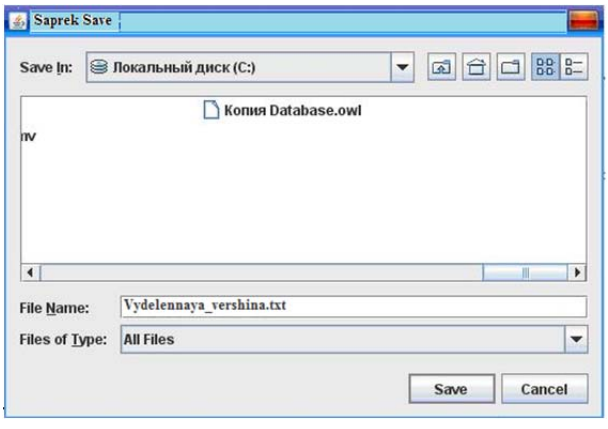

Fig. 7. Program interface for adding EC concepts selected in visual viewing mode from the ontograph "database systems (dbms)"

In Fig. 7, the selected concepts are recorded in the "selected_top" file.

6. Discussion of the research modifications of computer ontologies for electronic courses

The proposed ontological approach provides opportunities for learning at the conceptual level of knowledge, strictly structuring information for EC, concentrating training around the most significant concepts of the subject area, creating a tool that can automate the EC preparation.

In the proposed ontological approach, on the one hand, the ontology in electronic courses allows to strictly structure the concepts of the subject area and use the most significant concepts for EC, and on the other hand, computer ontology is the basis for the automation of the EU development instrument. There are ontologies of individual subject areas of sufficient depth (DB [8, 13, 14].

For the resolving the issue of preserving and further using the experience of teachers in subject areas, the results are ensured by including in the EC training scheme descriptions of methodological techniques obtained on the basis of the experience of teachers in a given subject area (Fig. 1, block 8).

For the create means of describing EC teaching methods and techniques in OWL, the results are ensured by the development of a scheme for supplementing the subject area ontology with an ontological description of the teacher's personal materials. (Fig. 4, Table 2), the results are ensured by the inclusion of teacher materials (tests, exercises, recommendations and examples of completing assignments – Fig. 5) into the system for constructing the EC CO.

For the automation of the teacher's personal materials inclusion the EC), results are achieved through the development of an appropriate interface and software (Fig. 6, 7).

The proposed solutions make it possible to close the problem area in terms of automating the addition of materials related to the teacher's personal experience to the EC by including them in the process EC preparation of an ontological description of the teacher's personal materials (Fig. 1, block 8, Fig. 5), the corresponding interface and software (Fig. 6, 7).

The advantages of this study compared to those known on this topic are due to the features of the proposed solution, which consist in an ontological approach to the description of materials related to the teacher's personal experience and the opportunity to automate one of the most labor-intensive processes when creating EC that arises due to this.

The limitations inherent in this study are due to the fact that the teacher's personal experience in ontological description relates to a greater extent to processes (Fig. 4, Table 2). Ontology editors are primarily designed for subject area concepts. In this regard, some of the teacher's personal materials will not cause problems with ontological description (tests, exercises, examples of assignments). However, part of the personal experience will be difficult to represent in ontological form (multimedia objects, educational films, books published by the teacher).

Limitations of the study include the fact that this approach may provide significant benefits in integrating teachers' personal materials. However, in this study has developed a procedure that is more likely designed for one teacher.

The heterogeneity of personal materials will hinder the proposed process of integrating the experiences of all teachers. For one subject area, many different ontologies will arise. Approaches to automating the integration of such an ontology are still unknown.

Considering the above, the authors believe that the topic can be developed in the following directions. First, to develop a standard ontology of elements included by teachers in EC, in addition to subject area concepts. Second, to develop a tool for automated integration of such ontologies. Third, to develop tools to extract methodology-related elements from the finished EC and combine them into an ontology.

7. Conclusions

1. An ontological approach to the description of the teacher's personal materials and EC preparation scheme is proposed. The peculiarity of the result, which lies in the ontological approach, makes it possible to solve part of the general problem of preserving and further using the teacher's experience, and provides advantages over known results including the ability to automate the processing of the teacher's personal materials. This result is explained by the properties of ontologies to structure material and the ability to store and process computer ontologies. Compared with known results, the obtained result allows including the teacher's personal materials in ontological knowledge bases.

2. It is proposed to use a description of the teacher's personal materials in the OWL language using the system of online design of ITC electronic courses. The peculiarity of the result, which consists in the inclusion of a description of these materials in the computer-aided EC design scheme in the OWL language, makes it possible to solve part of the general problem as the lack of tools for describing teaching EC methods and techniques in the OWL language and underuse of the computer ontologies potential in the educational process. This provides advantages in increasing the degree of automation of EC preparation over known results. This result is explained by the ability to process ontologies on a computer, which contributes to the automation of the EC preparation. Based on relatively well-known results, the obtained result allows increasing the degree of automation of the EC preparation.

3. A tool has been developed to automate the inclusion of teacher's personal materials in EC using Program interface for selection and automated modification of computer ontology and further EC construction. This solves a local problem associated with teaching methods when developing tools for automated construction of ontological knowledge bases.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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The study was performed without financial support.

Data availability

Manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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