

# Implementing of Interaction between the Components of the Automated System of Knowledge Testing by C++/Qt and PostgresSql

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**Abstract**—The components included in the developing system of knowledge testing that provides automated preparation of tests are considered. The system uses algorithms of the tests autogeneration from arbitrary text education materials. The interaction of the system components and software implementation of this interaction by C++/Qt and PostgresSql are presented. The tools used to develop the system are analyzed.

## I. INTRODUCTION

At the scientific-educational center "Information Technologies and Systems Modeling" of the Herzen State Pedagogical University of Russia last few years a several number of applied and scientific research for automation of departments are carried out. The network project in fields of the smart education is implemented together with the Chukotka branch of North-Eastern Federal University. The problems of organization and automated support of virtual educational space of the university as a whole are analyzed. These activities were the basis for the analysis and improvement of modern innovative solutions based on distance learning systems [1].

The development of the intelligent methods and technologies based on text processing algorithms was determined as one of the priorities of the research in the exploration of the automation of analytical support of making expert decision. The algorithm of the autogeneration test tasks from text materials was developed. The software used this algorithm was realized by high-level language [2].

The mentioned software is now transformed to the large automated information system of knowledge testing, which allows to carry out a full cycle of the intelligent learning on arbitrary disciplines. The learning process in this information system involves the introduction of students with educational materials on subject, as well as fixed control assimilated knowledge. The uniqueness of the system is the using of algorithm of the autogeneration tests from arbitrary text educational materials presented in a wide range of document formats. It is obvious that the developed system can significantly facilitate the work of the teacher, as well as improve the efficiency of the learning process [1-3].

The article describes the features of the developed system and their interaction. It also discusses and analyzes the

development tools of the whole system and software implementation of the interaction between the specific components of the system. In the conclusion of the article the information of the present development of the system of knowledge testing and prospects of the further work are represented.

## II. THE COMPONENTS OF THE SYSTEM AND THEIR INTERACTION

The system being developed of knowledge testing consists of the following components: the automated teacher's workplace, the automated student's workplace, the administrator's workplace and the server. The server contains the database with the information about students, educational materials and test tasks of specified materials [1], [3]. The deployment diagram shows the construction of the physical structure of the system in more details. This diagram is represented at the Fig. 1. On the physical level, the developing automated information system of the knowledge testing is presented as a system consisting of several major subsystems:

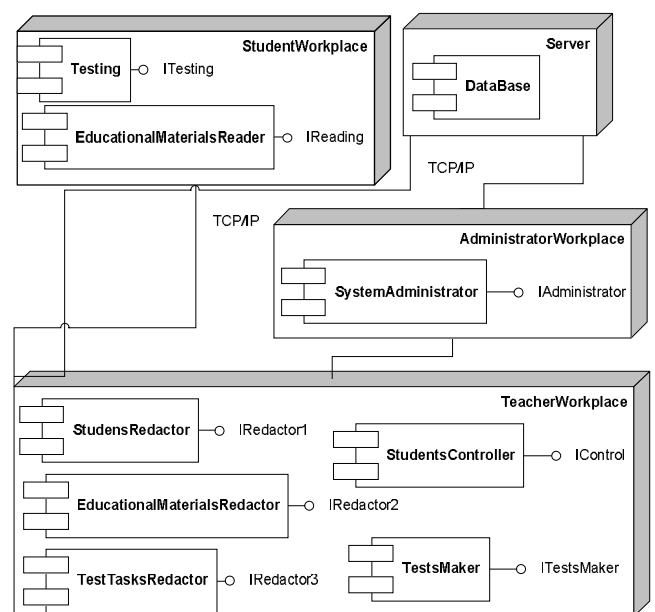


Fig. 1. The deployment diagram of the system of knowledge testing.

the system component provides a work of a teacher, the system component provides a work of a student, the database of the system and the subsystem provides administration of the developing system.

The diagram shows the possible interactions between the system components:

- The system administrator is responsible for the smooth operation of the database server and for the assignment of access rights to the database. He also looks after the up to date status of the teacher’s workplace and provides the access to a database server for teacher. At this stage of the development of the information system is supposed that the system administrator work is not automated. Setting the automated system of knowledge testing is carried out by changing the text configuration files. In the future, the development of appropriate software is planned.
- Automated teacher’s workplace performs immediate interaction with the database and with the automated student’s workplace. These interactions are provided via a stack of the transmitting data protocols TCP/IP. The teacher is responsible for maintaining up to date information in the database and transmits the information necessary for learning from the database to students by network. Such information includes educational materials for learning and test tasks for carrying out the control of retention of these materials.
- Automated student’s workplace interacts only with the teacher’s workplace. Thus all the necessary requests to the database server come only from the automated teacher’s workplace, which significantly reduces server traffic and increases system performance in whole. The student’s workplace provides the transfer of certain signals to automated teacher’s workplace. These signals include notification about the end of reading of educational materials and a number of notification about the progress of completing the test tasks.

As discussed previously now it is developing actively the described automated information system of knowledge testing with function of the autogeneration test tasks from the educational materials. At the moment is developed the software implementation between the following components of the system:

- the interaction between the automated teacher’s workplace and the database server;
- the interaction between the automated teacher’s workplace and the student’s workplace.

From the foregoing, it is clear that the developing automated system of knowledge testing is a complex composite system that allows to carry out a full cycle of study. The main function of the describing system is to provide intelligent electronic interaction between the participants of the educational working processes, as well as to allow the use in the educational process developing algorithm autogeneration of tests with the arbitrary educational materials.

### III. THE ALGORITHM OF THE AUTOGENERATION TEST TASKS

As noted earlier in the conducting research the algorithm of the autogeneration test tasks from arbitrary education text materials was created. This algorithm allows to find automatically all definitions from the text document, as well as to create the software multiple-choice questions from these definitions. The sequence diagram of the work of this algorithm is represented at the Fig. 2. This diagram shows the sequence of operations that the algorithm performs during its work. The participating in the work of the algorithm can be seen from the diagram objects.

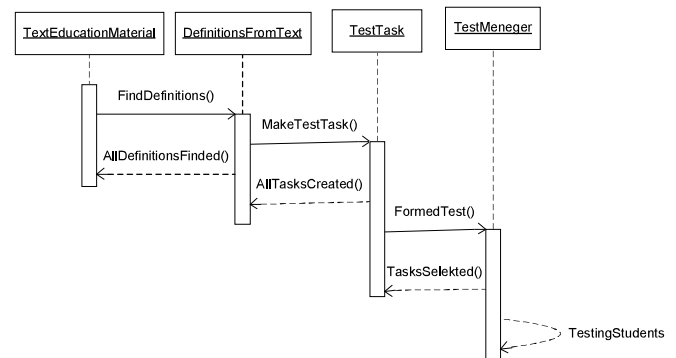


Fig. 2. The sequence diagram of the algorithm of the autogeneration tests

Autogeneration of tests can be carry out from the arbitrary text file that contains some definition. The source file taken from the arbitrary teaching material is presented in electronic form in the text format. The first version of the software has been implemented by means of the programming language C#, and the second version of this program has has been implemented by programming language Qt/C++. The validation of the program for a variety of subject areas is implemented. The effectiveness of the algorithm on the time performance and the evaluation of the complexity of the algorithm was assessed.

The text of the educational material on which the program will be make multiple-choice questions must be submit to the program. Only the correct text document is needed for the operate program. The program receives test tasks in a convenient form for testing. Each time when the program is called a new test in the form of multiple-choice questions is created by this algorithm. All questions are based on the definitions from the educational text material.

The algorithm of the autogeneration test tasks from the received text educational material consists of the following stages:

- 1) the algorithm creates a list of all the definitions from the text;
- 2) the algorithm creates a list of the concepts from all of the definitions from list, which was created earlier;
- 3) the algorithm selects n definitions from the list of all definitions as the base, where n – is the number of needed test tasks.

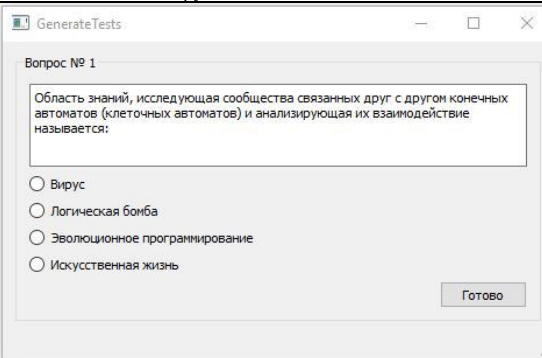
For each of these selected definitions the following sequence of operations is doing:

- a) the description of the concept is taken and paraphrased into the question, which is made by certain rules that are hardcoded in the program code;
- b) the concept is taken and placed on an arbitrary position-choice questions (each question offered four possible answers);
- c) the remaining answers are filled with arbitrary notions from the list of the concepts.

If it was selected the incorrect education material the program would end its work. Currently, the program works correctly with the no marked-up text data. These text data is often presented in a format \*.txt but there are other document formats, which allow to represent the text data in the required form for the program.

After compilation of the questions and answers, the program displays them in the form of tests on the screen, with the possibility of responses to each question. The example of the work of the autogeneration tests program is represented at the Table I. The algorithm of the autogeneration test tasks operates only with Russian texts. In the following table is the block of the text, which the algorithm of the autogeneration test tasks is identified as a definition and a window with the four-choice questions composed for this test definition is represented.

TABLE I. DEMONSTRATION OF THE WORK OF THE AUTOGENERATION TESTS PROGRAM

<b>Text of the definition</b>	Эволюционное программирование – это область знаний, исследующая сообщества связанных друг с другом конечных автоматов (клеточных автоматов) и анализирующая их взаимодействие.
<b>Displays questing from this definition</b>	 <p>The screenshot shows a window titled 'GenerateTests' with a question 'Вопрос № 1' and a text box containing the definition. Below the text box are four radio button options: 'Вирус', 'Логическая бомба', 'Эволюционное программирование', and 'Искусственная жизнь'. A 'Готово' button is at the bottom right.</p>

Each question is displayed in a separate window can be seen from the Table I. It is necessary for user to answer the current question in order to go to the next question. In the transition to the next question correctly takes into account the response received to the current question. Thus, upon completion of the test will be known total number of questions and the number of correct answers based on which the score may be set for the test.

Significant expansion of the algorithm of the autogeneration test tasks from the arbitrary text educational

materials is planned. Some of features that can be implemented by the algorithm shown below:

- the increasing the number of supported formats of documents that can be stored learning materials;
- the introduction the possibility of generating other types of the test tasks (as noted earlier is now algorithm generate only questions with four variants of answers);
- the adding the ability to control the process of the autogeneration the test tasks – setting the rules by which the algorithm will create a test tasks.
- the implementation of the autogeneration algorithm to the large automated information system of knowledge testing.

It is obvious that there are a big number of the prospects of the development of this algorithm. This list of the prospects is not limited to the above. Some more advanced of the algorithm of autogeneration test tasks from arbitrary educational materials are represented more detail in the conclusion of the above article. Currently, the main activities are focused on the development the automated information system of knowledge testing. The algorithm of the autogeneration test tasks from the arbitrary text educational materials is implemented to this system. This system will allow to make a complete cycle of learning processing.

#### IV. DEVELOPMENT TOOLS

As the main programming language for the implementation of the automated system of knowledge testing a C++ programming language was selected. To build the user interface was used version of multiplatform framework Qt with GNU Lesser General Public License. In the original the simple program by C++/Qt which performs definite sequence of actions was written (activity diagram which describes this sequence is given at the Fig. 3). As it was mentioned earlier now this program transformed to the large automated information system of knowledge testing.

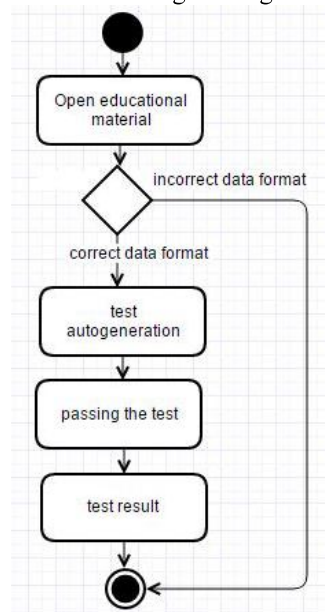


Fig. 3. The activity diagram of the original program.

For the organization of the database was chosen the free object-relational database management system PostgreSQL.

There are several major advantages that influenced the choice presented development tools. Some of these advantages are represented below:

- a wide range of different class libraries that provides the ample opportunities for using Qt;
- the applications written by C++/Qt are the cross-platform software, if that not cross-platform libraries were not used during developing;
- the PostgreSQL is cross-platform tool;
- the Qt library and the PostgreSQL database management system are the open source development tools;
- the Qt constantly develops;
- the Qt tools used signals and slots mechanism;
- the Qt documentation is competently composed and always kept up to date.

A big number of the different libraries of Qt allows the development of the system in most cases using a standard set of classes and not using the third-party libraries. This avoids a large number of programming errors and issues related to the introduction of third-party libraries in the code. Also this avoids the problems associated with combining the license of the development tools and subsequent licensing of the software produced.

It is worth noting that the bulk of the organization of information systems and databases interaction can be carried out by tools of PostgreSQL. PostgreSQL database itself is the most advanced open source database management system. It provides high reliability and stability, even at very high loads to the database server.

Sharing C++/Qt and PostgreSQL is quite common now. One reason may be related to allocate cross-platform and open source of both. Thus, the implementation of information systems developing by C++/Qt and PostgreSQL are possible in a large number of very different businesses. Currently these development tools are widely used operating systems for special purposes, which are mainly based on the Linux kernel. It should be noted that there is no need to install one operating system to a server and workplaces.

Thus, the developed means of C++/Qt and PostgreSQL automated system of knowledge testing can be used for a wide range of educational institutions, as well as to unite together a single educational network different branches of institutions or different institutions if it's necessary. The ability to use these tools for a special purpose operating systems significantly extends the use development system of knowledge testing. For example, special purpose operating systems can using in the military education institutes.

V. THE IMPLEMENTING INTERACTION BETWEEN THE AUTOMATED TEACHER'S WORKPLACE AND THE DATABASE SERVER

The interaction between the automated teacher's workplace and the database server allows teacher to perform a series of

actions listed on the fragment of the use case diagram at the Fig. 4. In this diagram fragment has only one character - a teacher, and all precedents reflect the actions related to the editing and accessing the database.

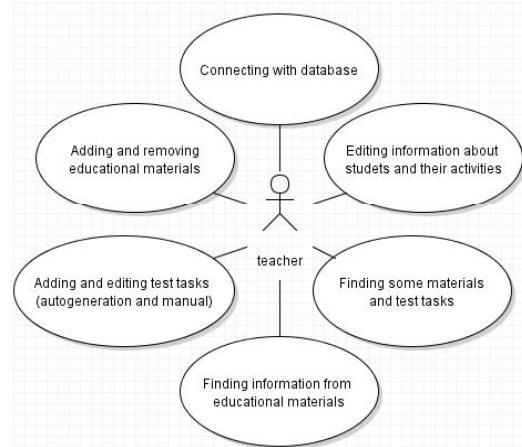


Fig. 4. The fragment of the use case diagram

The interaction of the information system of knowledge testing with database server hosted by a driver QPSSL, delivered with Qt. When the automated teacher's workplace starts working the instance of the class QSqlDatabase is created by using the QSqlDatabase::addDatabase ("QPSSL") method. The attributes such as port, host name, and the name of the database are assigned to the created instance. The system administrator is responsible for the correction of these attributes.

To start using his workplace the teacher must enter his personal login and password. These data also indicate attributes of the previously created instance of the class QSqlDatabase. All information of users of the database, as well as their rights to change and read tables stored in a database and can be edited only by the system administrator. Organization of access rights to the components of the database is organized by tools of the PostgreSQL database management system.

If all the attributes of an instance of class QSqlDatabase been set correctly, the connection to the database of electronic educational resources is established and the entering to the user interface of the automated teacher's workplace is carried out. Then the teacher can start full using of the system operation, performing all action permitted access rights. If at the logon were introduced the incorrect user data (user login, password or both of them) or there is no connection to the database server, the system will display the appropriate error message and stop its work.

Continued interaction between the teacher and the database is realized by using the classes from the library QtSql. Retrieving data from the database and writing data to the database is done by the organizing of requests for it from the source code. The code carries out the implementation of such requests is given in the Table II. The code is shown in a general form, the fragments which are responsible for the

implementation of the specific actions of the development program are removed from listing.

TABLE II. FRAGMENT OF THE CODE OF THE DATABASE INTERACTION LISTING

```

Qstring sql = ""; //sql selected request is located in the quotes
QsqlQuery query;
query.prepare(sql);
query.bindValue(":vall", vall); //set values to the sql code
if (query.exec())
    if (query.first())
    {
        //code of the actions with the information from the database
    }
    
```

From the foregoing, it is clear that the software implementation of the interaction between user of the system of knowledge testing with database server is carried out by the set of standard classes of the Qt, as well as by built-in PostgreSQL database management system. This method of implementation of the code ensures cross-platform information system of knowledge testing and this system easy adaptation to any educational institution or a network of such institutions.

VI. THE IMPLEMENTING INTERACTION BETWEEN THE AUTOMATED TEACHER’S WORKPLACE AND THE STUDENT’S WORKPLACE

The interaction between the automated teacher’s workplace and the student’s workplace allows users to perform a series of actions to implement exchanging of the data and various notifications to each other. The Fig. 5 shows the fragment of the use case diagram describing this interaction between the teacher and the student. All precedents reflect the actions related with the communication between users. Network interaction between the teacher and students involves reconstruction of the complete cycle of the educational process: working with educational materials, working with the tests, fixing the results of learning.

The interaction between the automated teacher’s workplace and the student’s workplace at the physical level is organized by means of protocols stack TCP/IP. For the organization of networking in Qt there is a special standard library QtNetwork. The library collected classes for working with various communication protocols. For the organization of the network by the data transmission protocols stack TCP/IP in this library there are the following classes: QTcpServer and QTcpSocket.

For the organization of networking at the automated teacher’s workplace as at the server class QTcpServer is used. In this case, the automated student’s workplace acts as client, and its work is organized with the help of class QTcpSocket.

Networking between system components to easily organize by C ++ / Qt tools by using signals and slots mechanism. One of the advantages of their usind is not needind to write complicated code to organize receiving notifications from client to server and back. The signals and slots also facilitate delineation of all incoming notifications to the server.

Such an organization of interaction between students and teachers not only provides the possibility of the educational process within the same institution, but also provides the possibility of the organization of educational process on the Internet. Thus, the automated information system of knowledge testing can be used for the distance learning. Also, the distance learning using the developing system is possible because the automated student’s workplace have easy functions and the data are obtained only from the automated teacher’s workplace and pass the information back.

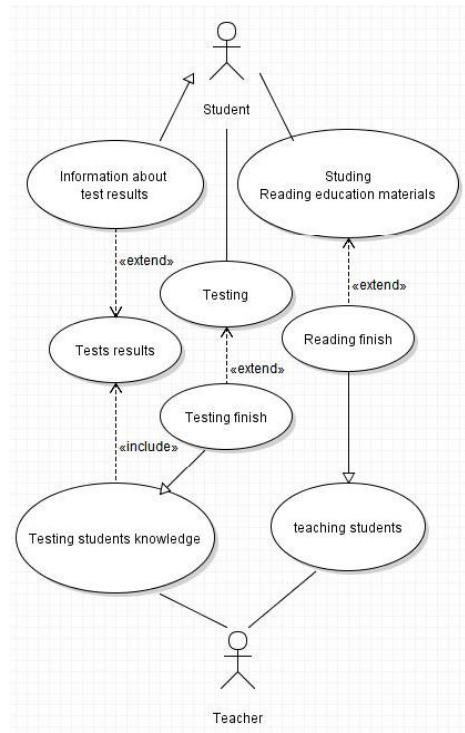


Fig. 5.The fragment of the use case diagram.

VII. THE CURRENT WORK AND RESULTS

Currently, the described information system is developed. Earlier first versions of the user interface of the automated teacher’s workplace and of the automated student’s workplace were developed.

At the top of the presented at the figure program window is the main menu, which allows you to switch between the following tabs: educational materials, test tasks, results and statistics of the education, system settings. The first tab is opened at the figure. It is a table with a list of currently available educational materials in the database and with the buttons for the control the contents of the table: the addition a new educational material to the database and the deleting selected material from it. The second tab is responsible for the preparation the test tasks to the current educational material using the algorithm of the autogeneration test tasks or manually. Autogeneration algorithm is now being modernized and are not included in the program. The third tab is responsible for keeping the statistics of the student performance. In this statistic includes attendance, the study the

educational materials and grade of the progress and the concluding tests of the students' knowledge. The fourth tab is responsible for the system configuration.

There is the software that implements the described interface by C++/Qt. Functional of the automated teacher's workplace is not realized completely at this moment. Now fully operational, only the first tab of the main window of this component of the information system.

The student interface currently conceived, but not implemented by software. There are two main functions of the automated student's workplace, which should be provided by the user interface: displays all received through the network educational materials and the passing the received test tasks. Work is under way to study the display capabilities of the different formats of the documents. As part of this work examines the various formats for storing text documents, and the C++/Qt libraries for working with them. Just the option of the using a Python libraries for parsing text documents and display them is considered. To implement the passing the tests interface can be used earlier written testing program with the function of the autogeneration test tasks.

The database of the automated information system of the knowledge testing is developed by PostgreSQL tools. There is a model of a database by the program is called the PostgreSQL Database Modeler or shorter the pgModeler. The models made in this program can be generated to the database by its tools. There is also a set of scripts that are included all the changes of the database at the stage of its development, and that, if necessary, can be supplemented with new ones. With these scripts, you can create a database and its initial setup on any PostgreSQL server from scratch without using additional software. The database contains educational materials, test tasks, information about the teachers and students, information about the teaching disciplines, and also the system and users settings and their access rights.

The interaction between the teacher's workplace with the database server is fully implemented and has an initial separation of access rights to the database tables to an administrator and a teacher. Networking between the automated teacher's workplace and the student's workplace is being developed at the moment. The programming tools of this interaction is represented earlier.

Thus, at present active work on the implementation of teacher and student interfaces and their relationship is conducted. Previously it implemented database providing work of the automated system knowledge testing and the interaction of the system and the server where database is located.

### VIII. CONCLUSION

In conclusion information about further work of the automated knowledge testing and information about the possibilities of development the algorithm of the autogeneration test tasks is represented.

The further development of the automated information system of the knowledge testing involves the implementation

of the full functional of the automated teacher's workplace and of the automated student's workplace. As previously noted part of this functionality has been developed. There is also a need to develop a single style interface for the whole system.

It also assumes the maximum automation the system administrator work. At the moment, the system administrator has not developed a separate program, allows you to configure the system quickly and efficiently. It is assumed that all necessary actions the administrator will be perform manually. In this case require a specific training of employees occupying the position of administrator of the system. Following the development of the administrator's workplace it is assumed that the configuration of the system will be able to deal with people without special education.

Also expected the introduction of the modernized algorithm of the autogeneration test tasks into the developed information system. The most important part of the development work is to develop algorithm of autogeneration. The possibility of obtaining the test tasks from educational materials in the automatic mode is make possible to talk about the uniqueness and novelty of the developed system.

Modernization of the algorithm of the autogeneration test tasks which allows the teacher to define the rules that will be prepared to generate test tasks from the educational materials is planned. The rules of the composition the test tasks will be stored in a database and can be used to generate tests in the future. This greatly expand the ability of the algorithm of the autogeneration test tasks: the selection criteria of the text educational materials that can be used to generate the test tasks will be narrowed and significantly increase the number of possible questions for the generate from text. At the moment, the rules of the composition the test tasks are described in the program code and cannot be changed by the user.

Currently the algorithm of the autogeneration test tasks works with the not tagged text data, that is, the algorithm is targeted mainly at the work with the format \*.txt. When applying the algorithm to the input file with tagged text data may cause unwanted errors in the composition of the questions and answers to them, as well as in their display. In the future, it is planed the introduction of the possibility of using a wide range of document formats, which can be presented educational materials. These document formats can include formats such as the text document of the Microsoft Office Word (\*.docx or \*.doc), the OpenDocument text format (\*.odt), LaTeX Documents (\*.tex) or cross-platform electronic document format - Portable Document Format (\*.pdf). There are a number of libraries in the C++/Qt to work with common formats of the text data. If there is no such libraries there is the ability to use third-party libraries to work with text documents, for example libraries of C++ or Python. The presented changes of the algorithm of the autogeneration test tasks allow the use this algorithm to almost any educational material that will significantly expand the scope of the application this algorithm.

Currently, the essence of the algorithm of the autogeneration test tasks based on the algorithms of the finding and the replacing occurrences of a the substring within



a string. In this approach, the algorithm of the autogeneration the test tasks is operational, but the efficiency is not high. In the future is planed the increase of the efficiency of the developed algorithm by using data mining algorithms. This will significantly enhance the ability of the algorithm, as well as improve its efficiency.

Thus, possible to say that the purpose of the writing the automated system of knowledge testing is the implementation into this system the algorithm of the autogeneration the test tasks from arbitrary education materials. At the moment, are working on the development of the software interface, but in future it is planned significant upgrade of the algorithm of the autogeneration of the test tasks from the arbitrary educational materials. It is possible that the developed system will be a breakthrough in the field of educational data mining (EDM) and bring the educational system to a new more advanced level.

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