4. Оптимальне значення функціоналів прямої та двоїстої задач з розміщеними відділеннями зв’язку (*модельні задачі 1, 2*) більше за відповідні значення у випадку з умовою розміщення відділень зв’язку (*модельні задачі 3, 4*).

Зведені результати наведено в табл. 1.

Висновки. Приведено результати оптимального розміщення відділень зв’язку, що надають декілька видів послуг абонентам з певної області та її розподіл на зони обслуговування кожним відділенням зв’язку по кожному виду послуг в залежності від попиту абонентів. За допомогою розробленого програмного продукту одержано графічну візуалізацію числових результатів та проведено їх аналіз.

Таблиця 1. Зведені результати застосування програмного продукту до модельних задач

Попит на послуги зв’язку	*Задачі з розміщеними ВЗ*			*Задачі з розміщенням ВЗ*		
	кількість ітерацій	***Оптимальні значення функціоналів***		кількість ітерацій	***Оптимальні значення функціоналів***	
		прямого, F_*	**двоїстого,** G^*		**прямого,** F_*	**двоїстого,** G^*
Нерівномірний	*модельна задача 1*			*модельна задача 3*		
в області Ω	108	4849,08	4861,12	86	4724,81	4715,03
Рівномірний в	*модельна задача 2*			*модельна задача 4*		
області Ω	50	4439,16	4455,84	80	4304,85	4326,32

ЛІТЕРАТУРА

1. Кісельова О.М. Розв'язання нелінійної неперервної багатопродуктової задачі оптимального розбиття множин з розташуванням центрів підмножин / О.М. Кісельова, В.О. Строєва// Питання прикладної математики і математич- ного моделювання. – Д.: ДНУ, 2010. – С. 155–164.
2. Кісельова О.М. Розв'язання нелінійних неперервних багатопродуктових задач оптимального розбиття множин з фіксованими центрами підмножин / О.М. Кісельова, В.О. Строєва // Питання прикладної математики і математичного моделювання: збірник наукових праць. – Д.: ДНУ, 2011. – С. 151-166.
3. Киселёва Е.М. Алгоритм решения нелинейной непрерывной многопродуктовой задачи оптимального разбиения множеств с размещением центров подмножеств / Е.М. Киселёва, В.А. Строева // Проблемы управления и информатики. – 2012. – № 1. – С. 40 – 53.
4. Кісельова О.М. Математичне моделювання та оптимізація розміщення сучасних відділень зв'язку, що надають різні види послуг / О.М. Кісельова, В.О. Строєва// Математичне та програмне забезпечення інтелектуальних систем: XIII міжнар. наук.-практ. конф., 18-20 лист., 2015 р.: тези допов. – Дніпропетровськ, 2015. – С. 94 – 95.

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Methodology of using interactive expert-training educational tools in teaching “Discrete Mathematics”

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The work is found out of the development and implementation by learning process automated means of studying. The description given by expert-training curricula that enable self-study content modules "Boolean functions" and "Graph’s theory". The technique was showen by using these software grocery Electronical test tasks to the organization evaluating the quality of assimilation studied materialsduring the study course of "Discrete Mathematics».

Роботу присвячено питанням розробки та впровадження у навчальний процес автоматизованих засобів навчання. Наведено описання експертно-тренувальних навчальних програм, які забезпечують можливість самостійного опрацювання матеріалу змістових модулів «Булеві функції» та «Теорія графів». Надано методику застосування цих програмних продуктів та електронних тестових завдань до організації оцінювання якості засвоєння опрацьованого матеріалу під час вивчення курсу «Дискретна математика».

Работа посвящена вопросам разработки и внедрения в учебный процесс автоматизированных средств обучения. Приводится описание экспертно-тренировочных учебных программ, которые обеспечивают возможность самостоятельного изучения содержательных модулей «Булевы функции» и «Теория графов». Приведена методика применения этих программных продуктов и электронных тестовых заданий для организации оценивания качества усвоения изученного материала во время изучении курса «Дискретной математики».

Introduction. Nowadays Ukraine has three-component standards of higher education, including specialist's educational qualification characteristics (EQC), specialist's educational professional training program (EPTP) and diagnostic tools of education quality. EQD includes a list of initial positions, professional functions, tasks and professional skills that are defined in the resilt of the research of the structure and content of the certain profession. Specialist's EPP is the selection of educational contents according to the criterion "essential competences and skills", that provides mastering the skills, defined in the EQC and ability to use them. Diagnostic tools of education quality include technologies that define:

- degree of the planned results achievement;
- adequacy criteria for the evaluation of the learner's quality of training;
- assessment tools.

Diagnostic tools of education quality - is the part of higher education, which requires continuous improvement, implementation of certain range of tools providing an adequate evaluation of the quality of education in preparing specialists in different areas. These tools currently include interactive educational and expert systems developed for a particular academic discipline. Intelligent training systems, which include the so-called expert-training systems, perform a didactic function of forming certain learner's competences and skills. They make it possible to mark the level of the learner's knowledge and skills, diagnose his mistakes and assess the quality of the acquired knowledge and skills.

At the present stage of development of education the priority directions include implementation of the informational technologies, focused on the realization of objectives of education and training. The process of informatization and automation of education initiates:

- improving and creating technologies of education system management;
- improving storage and distribution of teaching experience;
- creation and implementation of new methodological educational systems;
- creation and use of new techniques for monitoring and evaluation of knowledge level;
- distribution of distance learning technologies;
- enhancing the role of various forms of self-study.

Problem. Among the components of the automated learning systems, the most difficult to implement are software modules, so-called trainers, which allow to simulate the processes and tasks facing the learner during training studies. The creation of such programs is a challenging task. This is due to the fact that programming the simulation programs requires proficiency in knowledge in a particular area, and that often the information that is necessary for the creation of training programs is rather complex and specific. Designing these automated learning tools is based on technologies of interactive learner's support when solving problems that involve dialogue with the learner at each step of solving the problem. This dialogue lies in informing the learner of wrong steps in solving the problem, giving some tips or links that may help in correcting the mistakes.

The purposes of this work are:

• Development and implementation of the automated learning tools into the educational process, namely - interactive expert-training software modules "Boolean functions" and "Graph theory", designed to address teaching tasks in the study course "Discrete Mathematics";

• development of methods of applying interactive expert-training-software modules "Boolean functions" and "Graph theory" and the use of test technologies in teaching the course "Discrete Mathematics".

The results. Program simulators "Boolean functions", "Graph theory" ([1], [2], [3]) were designed for use in teaching the course "Discrete Mathematics". They provide the opportunity for the learner's self -study of certain number of problems in "Discrete Mathematics" course in simulator mode. These software tools allow the teachers to demonstrate different methods of solving problems of the course during lectures or practical classes, as well as assess the quality of the received practical skills in the execution of assessment tasks mode. To check the level of mastering the current theoretical material, along with the above mentioned programs, tests for each section of the course "Discrete Mathematics" were created and introduced for use. Electronic test creation tool easyQuizzy (http://easyquizzy.com/) was used.

The proposed software provide a combination of material of certain sections of the course "Discrete Mathematics" and software environment in which they are implemented.

The automated training tools were created with the help of C++ programming language in the QtCreatorIDE. The compiler used - MinGW (GCC). In developing the software cross-platform set of libraries for software development – Qt was used. Automated educational tools can work with operating systems: WindowsXP; WindowsVista; Windows 7.

The code of the software is cross-platform, due to Qt libraries using, thus in case of using appropriate compilers, the software will work with other operating systems. For example Linux, MacOS. The program is compatible with 32x- and 64h-bit versions of mentioned operating systems. The automated educational tools are bilingual. The learner has the opportunity to work in both Ukrainian or Russian-language interface.

The program simulator "Boolean functions" was designed for learning methods for solving problems of Boolean functions. It supports working with functions that depend from not more than eight variables (i.e. number of Boolean functions is 2256). Taking into account the isomorphism of Boolean algebra and Cantor algebra, the software module allows you to perform minimization of sets presentation in Cantor normal form.

Section "Boolean functions" in the course "Discrete Mathematics" involves the learner's mastering presentation of functions in disjunctive and conjunctive normal form (using tabular presentation as well as presentation of functions with the help of hypercube certain order) and methods of its minimization. In addition, the study of this section concerns the problem associated with determining the completeness of the system of functions (including basis properties). Also it is necessary to resolve the question of

reference of Boolean functions to so-called closed classes of Boolean functions (Post theorem about the completeness of systems of Boolean functions). An important class of problems is the representation of Boolean functions in other basic systems, particularly in Zhehalkin algebra as a Zhehalkin polynomial. Finally, as an important example of Boolean functions application, the problem of synthesis of logic circuits that implement Boolean function is concerned. In particular, the use of stages method to solve this problem ([4]).

All these tasks are rather bulky, and include though not complex, but large amounts of calculations. So during the class, the time limit does not always allow to work over the solving methods efficiently.

The use of this software module allows the teacher to demonstrate the problem solving of the section "Presentation of Boolean algebra elements. Minimizing of presentation" rather fast and the learner has an opportunity to work through the problem solving methods of this section on his own (if necessary being able to consult the teacher). The program allows you to work through methods for solving the following problems:

- construction of a full disjunctive and conjunctive normal form of Boolean function defined in decimal code;
- minimization of Boolean functions;
- presentation of the minimal forms of Boolean functions in the polynomial form of Zhehalkin polynomial;
- check on enclosing into the five main closed classes and evaluation of the completeness of a given system of Boolean functions;
- construction of the logic circuit by the method of stages, that implements the given Boolean function.

As part of the calculations and constructions is carried out by the program, the learner has time and opportunity to focus on the key stages of solving the problem and work more problems. The program is designed so that at certain stages of solving a particular problem the learner must answer the questions and only after the correct answer he is allowed to move to the next stage of solution.

In the assessment mode in the "Boolean functions" programme all types of tasks listed above are considered as one big problem with the study of properties of Boolean functions.

Program simulator "Graph theory" is designed to work with columns that have no more than 20 vertices. The software module allows to consider the problem to the section "Elements of graph theory" and allows you to:

- represent graph (oriented, undirected, weighted) with parallel construction of adjacency matrix;
- build degrees of adjacency matrix and reachability matrix;
- define basic cyclomatic matrix and the basic cutset matrix, build the spanning tree;
- calculate the diameter, the radius of the graph;
- sorting the tree tops.

The software module "Graph theory", as well as the program "Boolean functions", can operate in three modes: demonstration, training and monitoring.

As already noted, all proposed educational tools have three options: teaching, training and assessing. The teaching program option allows the teacher in the classroom to demonstrate the stages of solving the above mentioned problems, moreover, check the learner’s accuracy in problem solving. Training and assessing options are designed for the learner’s self-study. The first gives an opportunity for the learner to master the stages of solving some particular problem with the help of the software. The second is also a dialogue with the learner, but every step of the problem solving is assessed and after the completion of the work the software reports the mistakes and marks received by the learner.

While working in the training or assessing modes, the learner must answer the test questions and only after the correct answer he can move to the next step of the solving. If the learner completes the tasks successfully and passes all stages of problems solving, it gets a mark in 100-point scale. If the learner gives three wrong answers, the program offers a new attempt at solving this problem, if the problem is not solved after four attempts, completed the work of the program finishes and the learner gets unsatisfactory mark.

The following are examples of software interface (fig.1-2):

Statistical report in assessment mode is shown in (Fig. 3-4). Along with program simulators in the process of teaching the course "Discrete Mathematics" electronic tests for each section (on the base of EasyQuizzy) were created. Their aim is to control the quality of theoretical material mastering ([5]).

These tests are short-lasting, contain different types of questions, including: questions with one correct answer, multiple-choice questions, the open questions, matching. Such current testing allows the teacher to monitor the learner’s work over the theoretical part of the course. The teacher can also use this test program for homework. In this case the test program should be installed in the way that the learner gets satisfactory mark only under condition that all answers are correct. Also the learner can print the report of the test end send it by e-mail. This approach allows the teacher to work remotely.

Finally, the combination of electronic test and program modules "Boolean functions" and "Graph theory" allows the teacher to give evaluate learner’s work during the final test objective.

Conclusions. The designed complex consisting of interactive expert-trainig software "Boolean functions" and "Graph theory", as well as the set of tests allowed to realize the educational objective, namely

- to cover the most common tasks of sections "Boolean functions" and "Graph theory" and almost all the theoretical material of the course "Discrete Mathematics";
- to provide the learners with sufficient number of training tasks to reinforce their solving skills;
- to control the number of learner’s mistakes as well as to specify their nature at all stages of solving problems, that allows to analyze and identify gaps in the knowledge, competences and skills;
- to provide active self-study activity for the learner;
- to evaluate (with a high degree of objectivity) the quality of learner’s mastering the theoretical material and its practical applications.

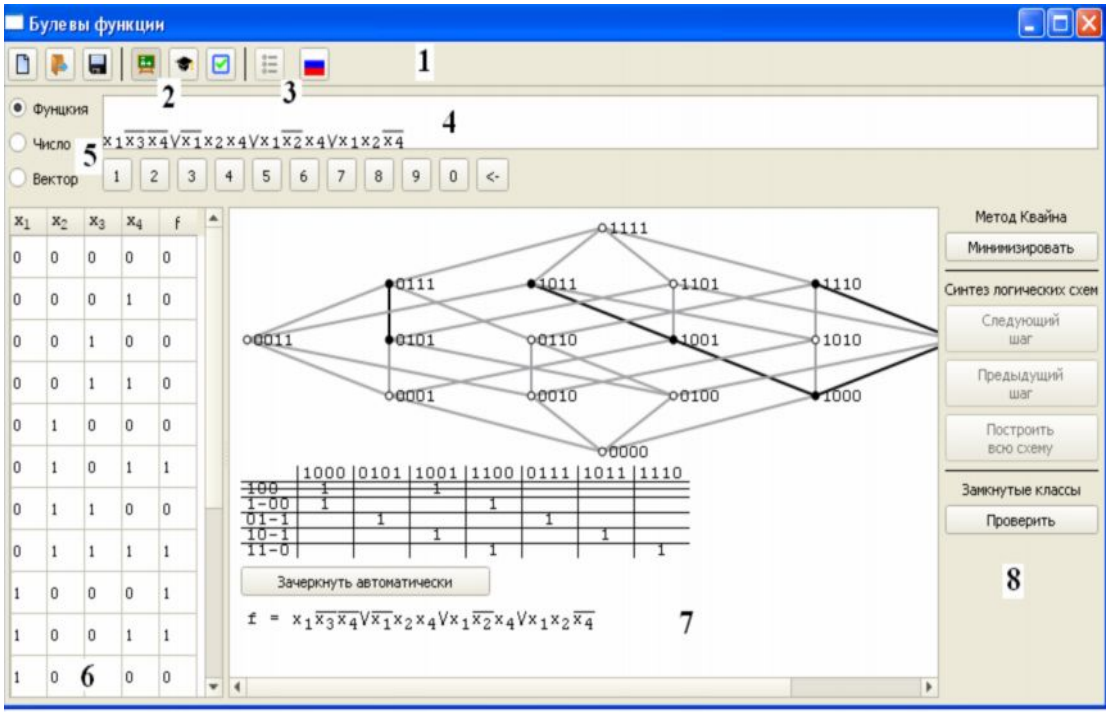

Fig. 1. Interface of the software module "Boolean functions"

1 – menu bar, 2 – selection buttons for modes "teaching", "training", "assessing", 3 – language selection buttons, 4 – function input field, 5 – bar of the type of function representation, 6 – tabular information output field, 7 – graphic and other information output field, 8 – Problem solving menu

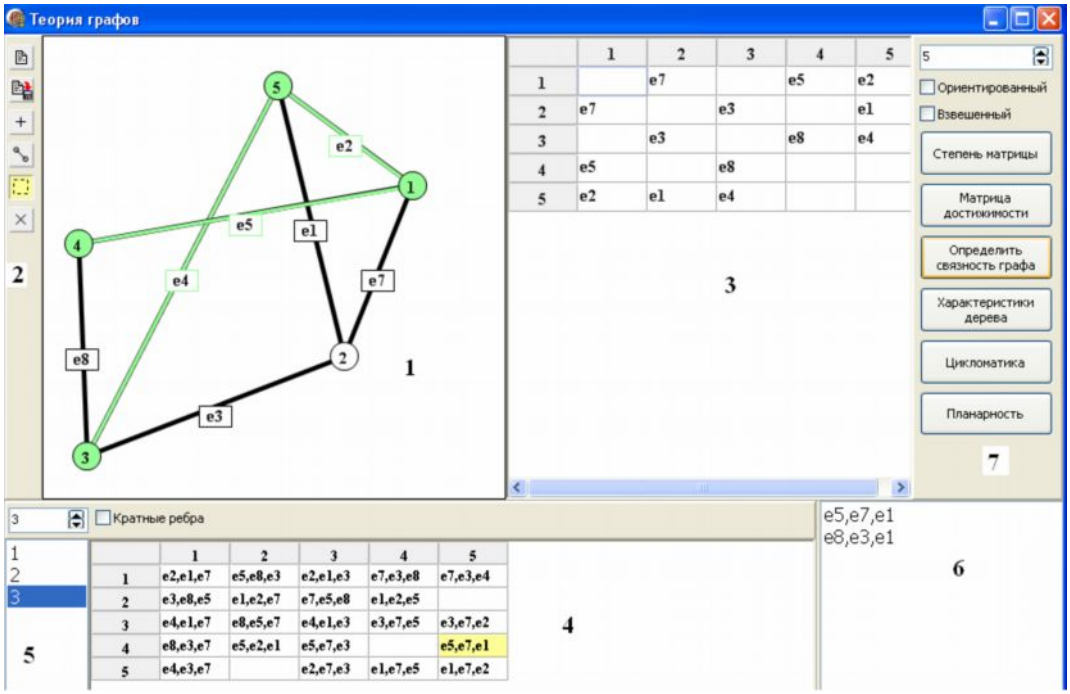

Fig. 2. The interface of software module "Graph theory"

1 – graph image field, 2 – graph constructing toolbar,

3 – adjacency matrix of graph field, 4 – degrees of adjacency matrices of graph field, 5 – exponent of adjacency matrix of graph, 6 – field of the routes of corresponding cell of a certain degree adjacency matrix, 7 – Graph task menu

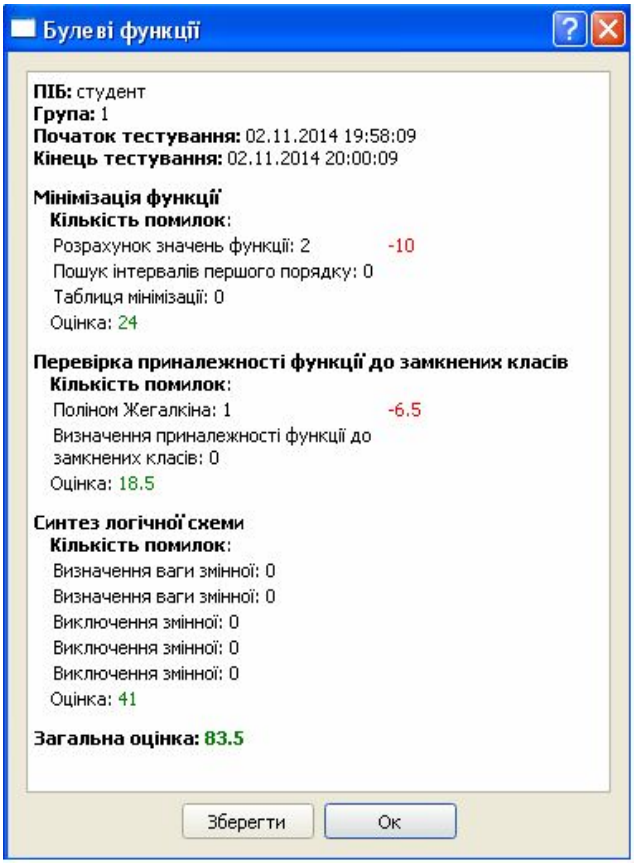

Fig.3

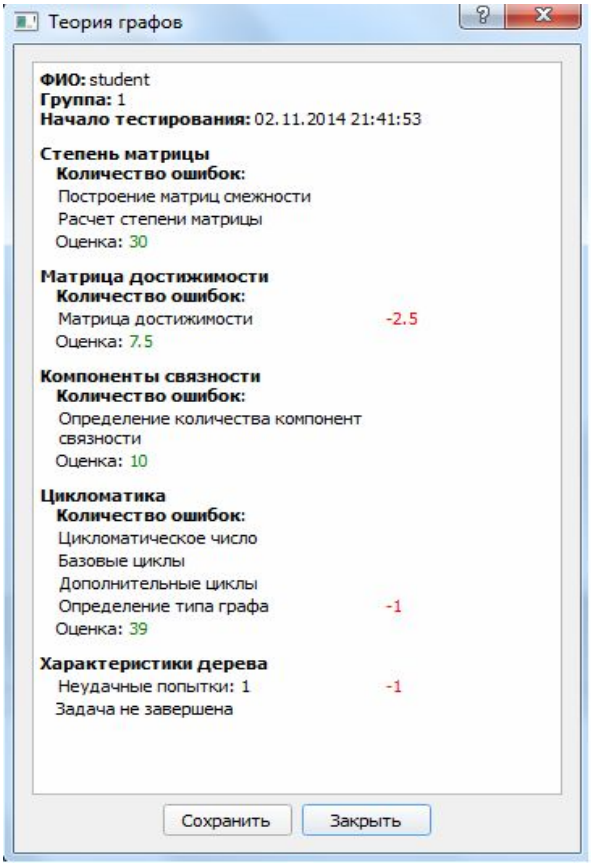

Fig.4

REFERENCES

1. Олійник Л.О., Крушельницький О.В., Черноусенко Н.В. Використання комп’ютерних технологій при викладанні курсу «Дискретна математика». Міждержавна науково-методична конференція. Проблеми математичного моделювання. Тези доповідей. м. Дніпродзержинськ. 2009. с210-213.
2. Олійник Л.О., Крушельницький О.В. Розробка інтерактивних компонентів автоматизованої навчальної системи до курсу «Дискретна математика». – Міждержавна науково-методична конференція. Пробле ми математичного моделювання. Тези доповідей. м. Дніпродзержинськ. 2012. с.170-171
3. Олійник Л.О., Крушельницький О.В. Інтерактивний експертно-тренувальний навчальний засіб «BoolFunctions». – Математичне моделювання. – 2013. – вип.1 (28). Дніпродзержинськ. ДДТУ. с 81-84.
4. Горбатов В.А. Основы дискретной математики: Учебное пособие для вузов.- М.: Высш. шк., 1986.- 311 с.
5. http://easyquizzy.com/

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