Features of the development of an automated educational and control complex for checking the quality of students

Dmitriy Bukreiev, Pavlo Chornyi, Evgeniy Kupchak and Andrey Sender

Bogdan Khmelnitsky Melitopol State Pedagogical University, 20 Getmanska Str., Melitopol, 72300, Ukraine

Abstract

The paper reveals the problematic features of developing an automated system for teaching students. The authors emphasize the need to study the specialized needs of the system before the development process and conduct an in-depth analysis of the needs of the modern educational process in order to identify the needs of the future product. In this paper authors develop a model of knowledge representation in the system and reveal the features of the mathematical apparatus for calculating and automating the processes of obtaining and evaluating students knowledge.

Keywords

development, educational, control complex, automated educational system

1. Introduction

Innovations in higher education are determined by state policy, one of the important priorities of which is informatization of all spheres of activity. The practice of modernizing higher education shows that with the help of traditional means of training and control, it is increasingly difficult to solve the problems of training modern personnel. In accordance with it, as well as with the requirements of the state standard of higher professional education in higher educational institutions, the role of training using ICT has significantly increased.

Many scientists have made a significant contribution to the theory and practice of using ICT as learning tools: Oleksandr Yu. Burov [1], Valerii Yu. Bykov [2, 3, 4], Svitlana M. Hryshchenko [5, 6], Arnold E. Kiv [7, 8, 9, 10, 11], Vladyslav S. Kruglyk [12, 13], Oksana M. Markova [14, 15], Mykhailo M. Mintii [16], Yevhenii O. Modlo [17, 18, 19, 20, 21], Pavlo P. Nechypurenko [22], Natalya V. Rashevska [23], Kateryna P. Osadcha [24], Viacheslav V. Osadchyi [25, 26, 27, 28, 29], Serhiy O. Semerikov [30, 31, 32, 33], Kateryna I. Slovak [34], Andrii M. Striuk [35], Svitlana V. Symonenko [36, 37], Viktoriia V. Tkachuk [38, 39], Tetiana A. Vakaliuk [40], Nataliia V. Valko [41, 42], Yuliia V. Yechkalo [43] and others. Methods of using the distance learning tools and the problems of blended learning were analyzed by Olga V. Bondarenko [44], Pavlo I. Fedoruk

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dessnight@gmail.com (D. Bukreiev); pavlochornuj@gmail.com (P. Chornyi); kupchak@mdpu.org.ua (E. Kupchak); sender@mdpu.org.ua (A. Sender)

0000-0002-5150-153X (D. Bukreiev); 0000-0002-8239-0211 (P. Chornyi); 0000-0003-1659-1450 (E. Kupchak); 0000-0002-8741-5625 (A. Sender)

[45], Nadiia O. Holiver [46], Volodymyr M. Kukharenko [47], Larysa M. Petrenko [48], Svitlana V. Shokaliuk [49], Mariya P. Shyshkina [50], Oleg M. Spirin [51], Myroslav J. Syvyi [52] and others. In their researches ways and ways of increase of efficiency of training with use of modern computer engineering, problems of computerization of natural sciences are considered, classifications of pedagogical software are offered. In the works [53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65] addressed the use of computer technology in teaching general professional discipline, the use of this technique for modeling processes and phenomena, compiling tests, solving problems and conducting quantitative calculations, developing software for self-control and standardized control of knowledge, computerization of pedagogical experiment.

Our theoretical analysis of the literature has shown that the use of new information technologies allows the student to better understand the nature of the course being studied, actively participate in the process of mastering its content, and independently monitor the acquired knowledge, skills and abilities. For their part, the teacher can adapt software tools in accordance with specific learning goals, quickly and objectively identify the level of development of educational material by students.

However, as for the use of new information technologies in courses of general professional disciplines, not all theoretical and scientific-methodological issues have been solved here. It can be stated that there is a mismatch between the needs of higher education institutions in the use of computer-based information learning technologies and insufficient development of the corresponding software packages.

As noted in the work of Viacheslav V. Osadchyi and Iryna V. Krasheninnik, nowadays one of the main deterrents to the improvement of professional training in such conditions is lower, compared to the standard term of study for a bachelor's degree (4 years) to 2-3 years of study with subsequent transition to professional training. However, during the two years of study it is impossible to provide the necessary time for full practical training [66], so the creation of an individual trajectory of the student allows to intensify the workload and reduces the time to obtain general competencies.

The question arises as to which of the modern approaches should be relied on to eliminate this inconsistency and thus improve the quality of teaching of general professional disciplines. One of the most relevant and promising in this regard is the competency approach, aimed at forming in future professionals key and a number of actual professional competencies during the shortened period of study.

2. Features of the educational process

The pedagogical process is always two-way and two-way and the analysis of educational and pedagogical goals, which sets the `"object"` of pedagogical influence, is no less (if not more) important than the analysis of the teacher's goals and the development of his pedagogical creativity. As noted by A.K. Markov, the level of development of goal-setting processes is the most important indicator of the formation of educational activities. We are talking about the quality of goals (novelty, non-standard, flexibility, sustainability), their validity and realism, the ability to overcome obstacles to achieving them. In the course of training there is a change of interaction of the educational purposes and motives, internal motives of educational activity,

in particular, cognitive and professional are formed. The most important factor in intensifying this process was the possibility of independent setting of educational goals. Classifications of goals act as a special measure of their commonality:

- global, general and private goals,
- attitude to educational structures that are responsible for their formulation and achievement,
- substructures of personality, the development of which they focus,
- goal description language.

Information technology is inextricably linked to forecasting because it has common goals. They are focused on achieving specific results, but require more rigor and responsibility in the design for direct application, which uses heuristic techniques, while forecasting allows extrapolation.

Important in our opinion in the study is the work of Viacheslav V. Osadchyi and Kateryna P. Osadcha, which identifies current trends in education informatization, among which scientists highlight: the introduction and dissemination of e-learning, services and tools for teachers, students, leaders and parents to cooperate with all the above participants in the learning process, the development of cloud technologies [67]. The authors emphasize that these tasks are leading in the scientific space. However, before determining the quality of the graduate obtained at the end of training, it is necessary to determine the factors that have the greatest impact on the learning process of students [68]. And as further noted in the study [69], the requirements of employers for engineering and technical knowledge and skills are constantly becoming more complicated. This is due to the accelerated evolution of technical skills, the emergence of new engineering professions and the penetration of technology into all spheres of human life.

The interaction of information technology for the teaching of general professional disciplines gives reason to believe that in the design of pedagogical technologies, new sources of forecasting are possible.

Pedagogical technologies with the use of information technology in a military university are associated with modeling, which, as a means of representation and transformation of an object that does not yet exist in reality, allows:

- lose, compare and evaluate standard pedagogical technologies,
- to simulate real processes of future pedagogical activity,
- accept the result of one of the alternative solutions to pedagogical problems.

The didactic model of teaching a general professional discipline as a variant of pedagogical technology should allow, if necessary, to make it possible to identify individual essential aspects of future activities, subjecting them to a more thorough logical analysis. Such modeling allows you to operate with unidentified objects and determine their stable properties, which is

extremely important in the military education system. The concept of pedagogical technologies, aimed at identifying their definition, structure, classification and justification of choice, is based on the analysis of theories of various sciences and related concepts.

In the process of professional training and scientific search, knowledge, skills and abilities are formed, there is a comprehensive intellectual development of students' personality and worldview, mastering the chosen specialty. All this happens through the main sphere – the mental activity of students: sensation, perception, representation, comprehension, memorization and other mental processes. As a result of mental functioning, all this is analyzed, synthesized through the harmonious action of higher nervous activity of a person. On the basis of this activity, a learning system is created that combines the content and form of scientific knowledge, establishing connections and relationships between the subjects studied and the phenomena of the objective world.

Trying to classify educational tasks by their "cognitive composition", we can observe that all types of tasks are grouped into five groups:

- tasks for reproduction of knowledge,
- tasks that require simple mental operations,
- tasks that require complex mental operations,
- tasks that require productive thinking for their solution,
- tasks for productive thinking with the generation on its basis of written or oral expression.

The process of professionally-oriented training was usually based on an inductive basis, from partial to general, by consistently performing a number of partial functions inherent in a military specialist. At the same time, each of these functions was studied in isolation from each other without any relationship. Therefore, the process of acquiring professional skills necessary for mastering complex equipment and the process of its operation was delayed.

So, building professional training on an inductive basis does not justify itself today. It seems most appropriate to build the learning process on a deductive basis from the general to the particular, so that professional skills and abilities of students are formed on the basis of general knowledge. This approach is used today to justify a new system and content of vocational training that corresponds to the modern development of vocational education. It requires the use of Information Technology. The new content of training using information technologies should ultimately lead to a change in Information Technologies of training that allow the development of expert training systems for assessing knowledge, skills and abilities. such expert systems should be based on the principles of the theory of step-by-step formation of mental actions and skills.

Among these principles we highlight the following:

- transition to the planning of the educational process in accordance with the level of knowledge acquisition in general discipline,

- introduction into the educational process of a quantitative measure of the degree of completion of the learning process in the form of the coefficient of assimilation,
- expert-educational system of assessment of knowledge, skills, abilities should be created taking into account the two above-mentioned principles.

Creation of expert-educational, expert systems on an estimation of quality of mastering of knowledge and completeness of process of training provides first of all the account of the basic principles:

- changing the role and function of the teacher, turning him into a specialist "consultant", which adds a new responsibility in his teaching activities,
- abandonment of the current method of training and the transition to individual training, especially important for self-training,
- transfer of the center of gravity of the educational process to the independent work of students,
- preparation of educational and methodical complex on the basis of taking into account features of computer technology of training. Each student is provided with full textbooks and various tasks in the discipline,
- abandonment of traditional forms of control and the introduction of individual cumulative index, which sharply increases the role of current, boundary and final control of knowledge, skills and abilities.

If the above principles are strictly followed, we can talk about the possibility of developing and using in the educational process of expert training systems and systems of expert assessment of knowledge, skills and abilities, their content of textbooks and manuals.

This indicates the need to increase the practical orientation of student learning. To implement professional training of students in educational standards and objectives requires the development and implementation of scientifically sound methods that reduce the time of students to master the actions and operations of professional activities without reducing the required quality of education.

The analysis of works of Pavlo I. Fedoruk showed that a significant amount of work is focused on forecasting trends in the development of educational space according to modern needs and, in particular, the development of adaptive testing tools for students. In his works, the scientist emphasizes the need to solve a number of problems of test control of knowledge in modern educational systems. In his works, the author notes that the methods and tools of classical test theory, despite the great potential of this technology do not solve many problems posed by the current level of education. He emphasizes that adaptive tests, in this case, can solve this problem and can be effectively used to solve any problem of optimizing the educational process - assessing the effectiveness of pedagogical innovations and technologies, monitoring [70]. Summing up the analysis, we can say that we can identify a number of positive features of the use of adaptive tests, namely:

- adjustment to individual possibilities of the student,
- increasing the accuracy of assessing the level of knowledge,
- reducing the duration of the test,
- reducing the degree of student fatigue,
- ensuring confidentiality by providing each student with an individual set of test tasks that correspond to his level of knowledge,
- simplification of the procedure for making changes to the task bank.

In the works of Valerii Yu. Bykov emphasized that the further informatization of the educational environment is based on computerized means of labor and requires a fundamentally new information environment [2, 3, 4]. Such systems are a further development of expert systems. They provide a quantitative assessment of system performance on the basis of selected criteria and models of alternative situations.

The development of methods of teaching general discipline of students with the help of information technology should be based on the integration of the provisions of the theory of the gradual formation of mental actions and block-module learning.

3. Features of system requirements

Teaching the general professional discipline aims to lay a theoretical foundation for understanding the essence of the physical and mechanical characteristics of the main structural materials and the technology of their production for their use in human activities. To ensure the consistency of knowledge and skills in the general discipline, practical classes are complex in nature. Individualization is achieved through an individual approach to students during practical, laboratory classes, consultations, current and final control. More hours are allocated for self-training of students. The acquired knowledge and practical skills are the basis for studying all subsequent engineering disciplines, they are the basis for technical design, construction and operation of airfields.

The main part of special courses is the organization and conduct of practical classes that make it possible to understand the features of the production process of a particular discipline. Practical classes are the basis of practical technology, so the process of improving the theoretical level of the content of the general discipline is a very important component. Strengthening the role of theoretical knowledge and conducting classes in accordance with the developed thematic plan is insufficient, and there is a change in the ratio of factual and theoretical material in favor of the latter, which leads to insufficient justification of theories in the minds of students and consolidation of acquired skills and knowledge.

A way out of this situation can currently be found when using information technology of training in the process of teaching the general discipline, which allows you to create a methodically based flow of information, including, in particular, factual material, which in the future can become the basis for the manifestation of systematizing and explaining functions

of theoretical knowledge. It is clear that creating an information flow is impossible without using an automated training complex. Information technologies open up an opportunity to better understand the nature of the object itself, actively engage in the process of its cognition, independently changing both its parameters and operating conditions. In this regard, information technologies can not only have a positive impact on the study of the general discipline by students, but, more importantly, on their mental development. The use of information technologies allows you to quickly and objectively identify the level of mastering the material, which is of great importance in the process of teaching a general professional discipline.

The main criterion for assessing the degree of information content of the educational process is the possibility of using training and testing programs in the educational process, which organize active work of students in a dialogue with the teacher. The advantages of using information technologies in the study of general disciplines include:

- improving the quality of teaching as a result of rapid assessment of knowledge,
- study group monitoring,
- operational management of the training session,
- effective and convenient work of the teacher in the group,
- clarity and visual control of knowledge,
- processing and storage of large amounts of information,
- accelerating the assimilation of material,
- acquisition of sustainable skills for practical application in the chosen field,
- manifestation of pedagogical creativity in the methodology and technology of the educational process.

Thus, the use of information technology for classes in general discipline in the system of automated student training does not impose any restrictions on the didactic structure of educational material and the choice of a pedagogical approach, but, on the contrary, contains a stage of creative approach by both teacher and student, organizing a closed interconnected cycle.

Summing up, we can say that, when creating an educational and methodological professionally oriented environment in the teaching of general professional discipline, different approaches are taken into account in developing a didactic model of teaching general professional discipline and include the following components: motivational, meaningful, personal-activity, managerial, evaluative. The selected didactic model reflects the conditions, stages and methods of teaching general professional discipline in the framework of professional training. The development of the model was based on the principles of systematization, scientificity, modeling, autonomy.

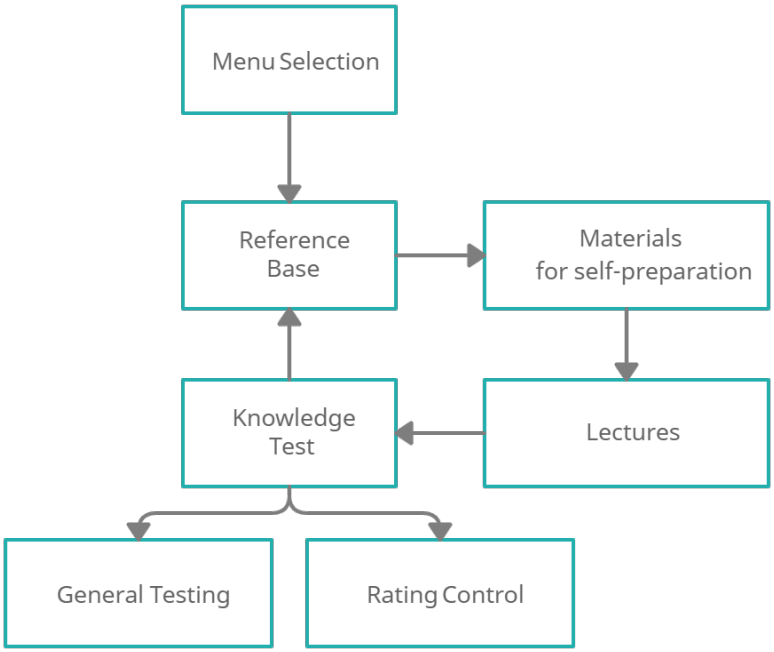

Figure 1: Virtual learning environment of the automated training complex

4. Structure of the software complex

On the basis of a tabular list of educational elements of a general professional discipline, didactic learning goals are developed, the achievement of which is controlled by a system of tests for the corresponding levels of assimilation of acquired knowledge. In automated knowledge control, tests are developed using a special methodology that takes into account the low, medium and high level of training of students. All training elements must be covered by testing, the number of tests developed for each training element is unlimited and can be constantly updated, since the training complex has a modular structure. Unlike traditional tests, automated tests involve the content of reference answers in the general discipline. After conducting knowledge testing in a computer classroom, the coefficient of knowledge acquisition by students is calculated, which is the basis of the created expert system for assessing the success of the learning process.

The coefficient of assimilation of knowledge varies from 0 to 1. if the coefficient of assimilation is greater than or equal to 0.7, the learning process is considered completed, specific knowledge is obtained and skills are acquired, and the coefficient of assimilation of knowledge is used in monitoring the rating control when calculating the rating: by semester, by specialty, individually and in a group test, which is extremely important for analyzing the assimilation of the course. The virtual learning environment using an automated training complex has a block structure, which is reflected in the figure 1.

As the automated educational complex of training of general professional discipline corre-

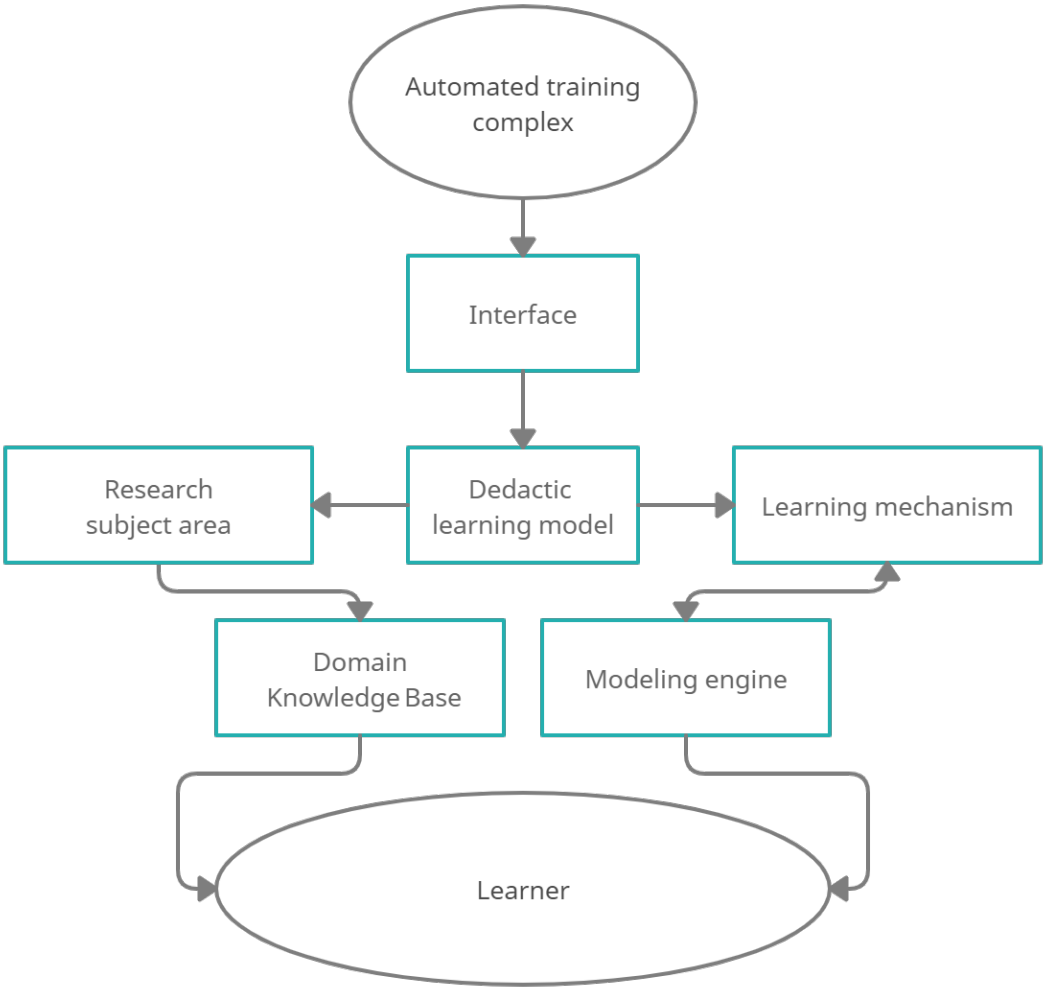

Figure 2: Homeostasis structure of knowledge transfer

sponds to the general requirements shown to educational controlling complexes, it is focused on achievement of the purposes set by the teacher and combines traditional and information technologies.

When using an automated training complex, both individual and group training can be used. In the context of learning, the complex has a homeostasis structure of knowledge transfer.

The global purpose of the automated educational complex is to prepare students for full and effective participation in social and professional fields in the information society. At its application there is a change of relations between the teacher and the student. They become a process of joint creativity (figure 2).

The automated training complex is a training, testing and monitoring program compiled according to the didactic model of PC formation when teaching a general professional discipline.

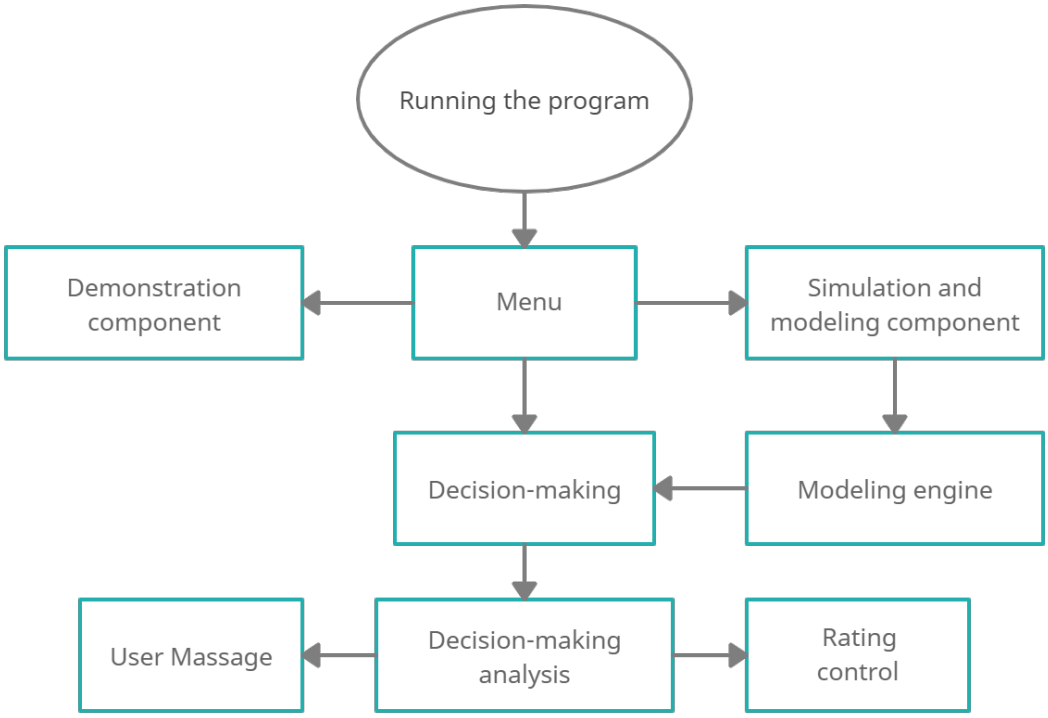

Figure 3: The functional structure of the training function of the automated training complex

The program is prepared in the Visual Studio environment with an integrated Shell and special navigation tools for viewing. In the Visual Studio System, there is a special form designer that allows you to prepare windows of the future program in the form of forms. The program is focused on internet technologies that allow you to deploy databases and build multi-level modular software packages with built-in application servers. The program is implemented in the client/server architecture and consists of several modules, each of which is significant and has its own algorithm. Software modules start working from the moment they are launched and do not require any additional configuration.

After registering the user, you need to determine the operating mode on the monitor screen. To conduct self-training or the next lesson, you need to use the menu view of the automated training complex. It contains: training, lecture, testing unit of self-training, monitoring of rating control of knowledge. Depending on the pedagogical task, the appropriate level is selected, and the program works according to the selected branch and a certain algorithm (figure 3).

Automated training complex provides for the presence of three components:

- demonstration, which displays information in accordance with a pre-designed scenario,
- simulation-modeling, which allows the user to control the dynamics of the learning process,

- controls the component that analyzes the user's work.

From a methodological point of view, all parts are in demand. If the educational part of the program is selected, the algorithm of the structure of the educational function of the automated educational complex has the following form (figure 3).

Working with the lecture course, the user works with the electronic textbook, gradually pressing the preview button and first selecting a topic from the list of menu sections on the screen, the thematic plan of the discipline is constantly consistent with the selected learning elements. The student on request can print out any lecture and view the physical properties of the materials from the reference database, learn the goals and objectives of the study, as well as read the list of references.

Simultaneously with the study of theoretical material, you can test your knowledge by choosing the option of testing knowledge. The testing unit for checking the quality of knowledge, skills and abilities reflects the systematic content of the general discipline and provides an objective check of the level of academic achievement. Tests are divided into classes by level:

- tests in practical and laboratory classes – a simple test,
- tests of increased complexity by topic – mixed test,
- residual knowledge tests – a control test for general disciplines.

In its form, the test is a system of tasks. Test tasks in the general discipline have a short form, so that each one does not take much time to complete. Work in each test block is individual.

The block of tests based on current material works according to the principle: question – answer based on time characteristics and contains approximate answers, of which you need to choose the correct one. Text appears on the screen, and questions and several possible answers to them are displayed in turn. After answering the questions, a rating is given. The accumulation of individual grades obtained on tests allows monitoring the assimilation of each topic of the general professional discipline both separately for each cadet and for the group as a whole.

When performing tasks on self-preparation for classes, it is sometimes very convenient to use testing on lecture topics of the general professional discipline. Simple tests contain material from practical and laboratory work. In a complex test, a mixed test consists of thirty tests and contains questions on the topic of a general professional discipline, while a control test consists of sixty tests and contains questions to determine in-depth knowledge in a general discipline. It can be used for self-certification and verification of residual knowledge in the general discipline.

The ambiguity of tests developed for teaching a general professional discipline is obvious. Each of them complements each other. The test curve determines the dependence of the test subject's actual rating. Training typical situations are selected by difficulty level only taking into account previous test checks. The curve is the average straight line between the characteristic curve of a light and heavy test (figure 4).

The result of the experimental study is expressed in a test score. Test scores are located on special scales, the score obtained with the help of tests is more accurate and differentiated than

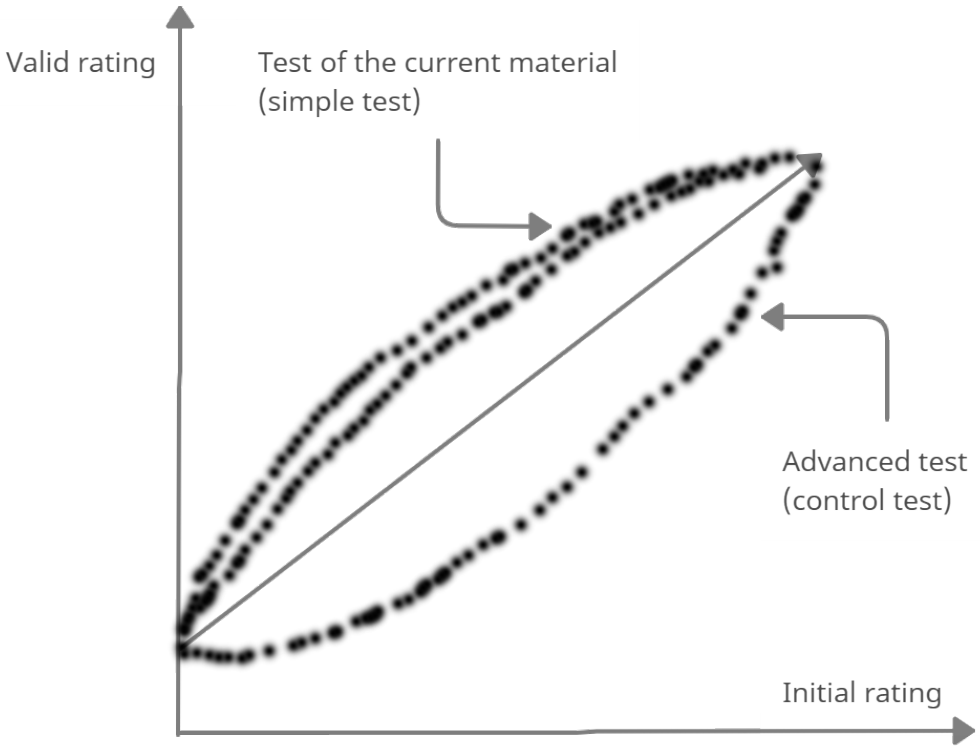

Figure 4: Dependences of the actual rating of the tested person on the characteristic curve of the test

traditional. If you look at the distribution of frequencies of actual scores depending on the characteristics of the test after a pedagogical experiment, the abilities of the tested were distributed according to the normal law. Performing tests independently allows cadets to conduct self-preparation for classes and eliminate gaps in the assimilation of lecture material, thereby increasing their professional level.

After studying the general discipline, the total coefficient of mastering of each student is calculated according to the formula:

$$K_a = K_l/i * n,$$

where: K_a is the total coefficient of assimilation after studying the topic; K_l - a separate coefficient of assimilation on the i-th test; n - the number of topics in the general professional discipline.

At final control of knowledge the received general factor is considered as follows. At K_a- = 1.0 – 0.9 the grade "5" is set, at K_a- = 0.9 – 0.8 – a mark "4", at K_a- = 0.8 – 0.7 – a mark "3" and at K_a < 0.7 – a mark "5".

5. Conclusions

The problem features of development of the automated system for training of students were opened in the work. Thus, it was emphasized the need to use a competency-based approach, which in its work is aimed at forming in future professionals key and a number of actual professional competencies during the shortened training period. The pedagogical process is always two-way and two-way and the analysis of educational and pedagogical goals, which sets the "object" of pedagogical influence, is a more important factor than the analysis of the goals of the teacher and the development of his pedagogical creativity. It was emphasized the need to study the specialized needs of the system before the development process and conducted an in-depth analysis of the needs of the modern educational process in order to identify the needs of the future product. During the analysis it was determined that information learning technologies allow the development of expert-educational systems for assessing knowledge, skills and abilities, such expert systems should be based on the principles of the theory of gradual formation of mental actions and skills. Among these principles were the following: the transition to planning the learning process in accordance with the level of knowledge acquisition in general discipline; introduction into the educational process of a quantitative measure of the degree of completion of the learning process in the form of the coefficient of assimilation; expert-educational system of assessment of knowledge, skills, abilities should be created taking into account the two above-mentioned principles. It was emphasized that the development of methods of teaching general discipline of students with the help of information technology should be based on the integration of the provisions of the theory of the gradual formation of mental actions and block-module learning. The developed model of knowledge representation in the system and reveals the features of the mathematical apparatus of calculation and automation of processes of obtaining and evaluating students' knowledge, so the automated educational complex provides for three components: demonstration, which displays information in accordance with pre-developed scenario; simulation-modeling, which allows the user to control the dynamics of the learning process; controls the component, which makes an analysis of the user. The block of tests on the current material works on the principle: the question – the answer taking into account time characteristics and contains approximate answers from which it is necessary to choose the correct one. When performing self-preparation tasks, it is sometimes very convenient to use testing with lecture topics of general professional discipline. Simple tests contain material from practical and laboratory work. In the complex test - a mixed test consists of thirty tests and contains questions on the topic of general professional discipline, and the control test consists of sixty tests and contains questions to determine in-depth knowledge of general discipline. The result of the experimental study is expressed in a test score. Test scores are located on special scales, the score obtained by the tests is more accurate and differentiated than traditional

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