# Creating of an Educational Environment Using Onotology-Based Approach to E-learning Systems

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**Abstract**

The article disclosed the meaning of the concept of "educational environment", describes the technology of creating such an environment based on ontology-based approach to e-learning systems, namely its components: conceptual, semantic, procedural and control-correction. The process of presenting e-learning content, which is based on a certain set of logically related blocks (chunks) and its properties, is described.

The essence of didactic and content ontologies of academic discipline is revealed. Examples of the application of technology in the study of disciplines: "Computer Graphics and Multimedia", "Linear Algebra", "Calculus", "Data Structure", simulated interdisciplinary connections using chunks.

**Keywords** [1]

Educational environment, e-learning, technology of creating, chunk, didactic ontology, content ontology.

## 1. Introduction

Today's higher education is aimed at updating its content and forms, education of responsible personality, ability to self-education and self-development, which contains critical thinking, processes various information, uses the acquisition of knowledge and content to creatively solve problems, changing the right to a better life. Based on the above, the ratio of support for higher education is the education of a professional, a person who will be offered in his future life to create material and spiritual values that will determine better social life and life, analyze the impact of these changes, create new and prove the value of the created professional civil society.

It is the educational space, which is dominated by the cognitive activity of the student in time is a factor in the development of motivational (motive of cognitive interest, desire for achievement, self-development), cognitive (conceptual, divergent thinking, intellectual skills, reflection), social (communicative skills). quality) areas of personality of the figure. The technology of construction of such space for classroom learning [1,2] and information technology of e-learning on the basis of ontologies [3, 4] are offered. However, today, when the COVID-19 virus is detected in the world, e-learning is becoming increasingly relevant and popular. We support the position of Declan Dagger, Alexander O'Connor, Séamus Lawless, Eddie Walsh and Vincent Wade [5], who believe that e-learning is an innovative technology aimed at professionalizing and increasing the mobility of learners and at the current stage of IT development. it can be considered as a technological basis for the fundamentalization of higher education. The main advantage of e-learning, according to V. Kukharenko, is its flexibility and adaptability to the needs and capabilities of students, who generally

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do not attend regular classes, but work at a convenient time (for both teacher and student) for such work in convenient place and convenient pace [6]. And this helps each student to build an individual trajectory of personality development of the future specialist. An important feature of e-learning is the new role of the teacher: the teacher coordinates the educational and cognitive process, adjusts the course he teaches, creating e-support as a development.

A number of researches are devoted to the implementation of e-learning projects within the system of self-education of Ukraine and Western countries (V.J. Hasson, H. Becker, R. Berger, V. Blank, D. Britel, A.A. Andreeva, M.V. Moiseeva, E.S. Polat, V.M. Kukharenko, V.V. Oliynyk, D. Riel) [7, 8].

Analysis of the scientific literature makes it possible to state that to ensure the effectiveness of e-learning, it must be combined: a combination of synchronous and asynchronous. For example, in synchronous learning, the student learns to communicate remotely in a simulated professional environment. These can be online role trainings, when the student assumes a certain role according to the proposed Requirements and Acts within this role. Preparation for commercial role trading – self-education is carried out through asynchronous learning: Use chats, Various messengers, audio or video, forums, ETC. Thus, combined e-learning contributes to the development of dialogic links in the structure of thinking: "thinking first for yourself" (hanging a hypothesis), "thinking first for the other" (the ability to occupy the position of the Other and think from his side), "thinking together with others" (designing a new product). Combined e-learning helps each student to understand how right he is completely, partially or wrong on the way to learning the profession.

The purpose of the article is to reveal the meaning of the concept of "educational environment", a description of the technology of creating such an environment based on ontology-based e-learning systems.

## 2. Technology of creating of an educational environment based on ontology-based approach to e-learning systems

In the context of our research, the educational environment is an e-learning environment in which the student transforms from a reader into an active seeker of new information and examples of its use in various educational and (or) professional situations. The leading means of active thinking of the student is a situation of reflection - a situation of curiosity, doubt, search. It is possible to organize the named situation in the e-learning environment in different ways. At least we distinguish two directions. Let's describe them.

The first direction. An example of reasoning with the help of a certain text or a pre-prepared video is presented. through the formulation of problematic questions draws students' attention to the dialectical movement of thought to the truth, making them as if participants in scientific research.

The second direction. The teacher gives students the opportunity to search for new information, directing their thoughts with heuristic questions: where?, when?, how?, where?, what?, why? etc.

This presentation of information promotes the development of students' logical skills, namely:

- identify informative and logical blocks, understand the differences and connections between them;
- to form true and false simple judgments, to turn a true judgment into a false one with the help of the particle "no" and the words: "all", "some", "none", "at least one";
- find patterns, make hypotheses;
- to prove one's point of view by reasoning by analogy or by simple deductive reasoning.

We will reveal the technology of building an educational environment based on ontologically controlled e-learning systems. Given the position main scientists that in the construction of any technology is a systematic approach that covers all major aspects of the development of the learning process: from goal setting, design of the learning process to test its effectiveness [6, 7, 10]. The technology of building an educational environment based on ontology-based approach to e-learning systems, in our opinion, is a dynamic system that covers all parts of the learning process: purpose, content, forms, tools, focuses on the development of cognitive interests, students acquire professional knowledge in the form of flexible systems suitable for use in various educational and professional situations, professional skills necessary for effective professional activity. In general, the technology is aimed primarily at developing the creative potential of students and has the following components: conceptual, semantic, procedural and control and correction.

We describe each of these components. The conceptual component of technology includes an interconnected system of targets: developmental, educational and certain psychological and pedagogical conditions of e-learning. Educational guidelines include the acquisition in the learning process of knowledge in the form of flexible systems suitable for use in various educational and professional situations, the means of mental activity; skills to reproduce in educational activities the logic of scientific knowledge.

Development guidelines are aimed at the development of conceptual, creative and divergent thinking, intellectual and creative skills. Educational guidelines are aimed at helping students in self-determination and self-development, education of perseverance, organization, endurance.

Among the psychological and pedagogical conditions of e-learning we distinguish the following:

- realization by each student of a free choice of a trajectory of study: each student independently chooses a trajectory of development, consciously choosing for themselves tasks differentiated on level of complexity for independent or control work, gradually mastering knowledge and skills of the actor.
- problem-based learning as a mechanism for developing a situation of reflection in the electronic environment: we recommend starting each new topic with a specific educational (professional) task, to solve which students lack certain knowledge and skills. This nature of the task is a certain basis for the emergence of interest in the process of cognition, a sense of the need to understand new information for further professional development. Organizing the situation of reflection in the electronic environment, the teacher helps students on the basis of observation, analysis, comparison of a number of facts, considerations, both independently and through various Internet sources, while showing guesswork, creativity (heuristic and research method of obtaining knowledge) , come to the realization of new information, drawing certain conclusions, some students discover a new (original, rational) way to solve a problem.
- Stimulation of intellectual activity: the driving force of success in learning should be the inner need, which is aimed at fully satisfying their intellectual and spiritual needs, as well as, very importantly, effective self-realization, asserting in the process of work both in their own eyes and in the eyes of peers. That is, for a more effective deployment of intellectual activity, the dominant in the hierarchy of motivation of intellectual activity should be the motive of interest, the desire for achievement, ie the desire to create their own developments. To this end, the teacher must provide an electronic resource with adequate tasks. According to the student's intellectual contribution, the teacher must develop a scoring system.
- Ensuring communication with the student audience In order to ensure a constructive relationship with the student audience at the end of the study of each module of the discipline, we advise teachers at the final seminar (practical) lesson to offer students analytical work, which contains the following tasks (questions): a) name and briefly describe the conceptual apparatus that you have mastered, mastering this module; b) how they prepared (did not prepare - explain the reason) for the current seminar, practical, laboratory classes; c) what difficulties arose during the preparation for seminars, practical, laboratory classes, how did you cope with them; d) whether you felt the practical significance of the material of this module, justify your thoughts; e) Your suggestions for enriching the content of this module; e) Your vision of conducting lectures, seminars, practical, laboratory classes. The semantic basis of technology includes the process of presenting educational information, the core of which is a certain new chunk [15, 16] and its properties. The process of forming any chunk should contain the following components.
- outlining the features of the concept as a result of finding common and different in the group of studied concepts;
- selection of the nearest generic concept;

- characteristics of species differences (selection of features that distinguish this concept from others in the outlined genus);
- selection of compatible and incompatible concepts for this concept;
- specification of the application of the concept: solving certain educational and (or) professional challenges.

The procedural component of technology covers a system of tasks aimed at applying knowledge in practice, in professional activities.

The control and correctional basis of technology includes methods of control and self-control, which should help the teacher to correct the process of formation of professional knowledge and skills, to encourage each student to higher achievements.

## 3. Chunk-oriented model of an ontology-based approach to e-learning system

Modern ontology-based information systems are designed to conceptualize ontological categories and improve the hierarchical structures of entities at all levels. [12]. At the same time, ontological principles act as a unifying mechanism between scientific knowledge of a particular subject area and general knowledge focused on ensuring the interoperability of educational systems [13].

The ontology of the discipline is based on the ontological system.

The proposed meta-ontology of the discipline consists of two parts [14]:

$$O^{Meta} =< O^{Didactic}, O^{Content} > \quad (1)$$

where $O^{Didactic}$ – didactic ontology of the discipline;
$O^{Content}$ – content ontology of the discipline.
In turn, the didactic ontology of the discipline is represented by three:

$$O^{Didactics} =< Ch, L, R >, \quad (2)$$

where $Ch = \{ch_i\}$ – the set of chunk names that make up the didactic ontology;
$L_i = \{l_{1_i}, ..., l_{m_i}\}$ – the set of links to content elements (Fig. 1).
$R$ – set of relations, while two relations are considered $R_1$ та $R_2$:
$R_1 \subset Ch \times Ch$ – the relationship is “studied after”;
$R_2 \subset Ch \times L$ – the relationship “chunk is related to acontent item”.

With the help of the conceptual component, the sequence and individual trajectory of the study of chunks is determined. The conditions for the study of educational material and didactic tools (lectures, audio-video material, practical tasks, tests, tests) are also determined.

Links to content elements link content blocks within a single discipline across different types of content, whether it's a text file, a presentation, a video file, a test, or a test. They also associate chunks with content from other disciplines. Chunk points to a set of logically connected learning material generalized to a topic presented to a student. The relation of didactic following between chunks indicates the order of following the educational material.

The didactic ontology of the discipline $O^{Didactics}$ connects educational objects, namely lectures, practical and test tasks, which are determined by chunks. On the other hand, didactic ontology reveals the conceptual and semantic components of the educational process.

In turn, the subject area is represented by a content ontology of the discipline, which is presented as a set of chains: *essence – link(relation) – description, which is preceded notation:*

$$O^{Content} =< N, E, L, D > \quad (3)$$

where, $N$ – notation;

$E=\{E_i\}$ – cortege of essences of subject area;
$L$ – links between essences and descriptions;
$D=\{D_i\}$ – cortege of descriptions.

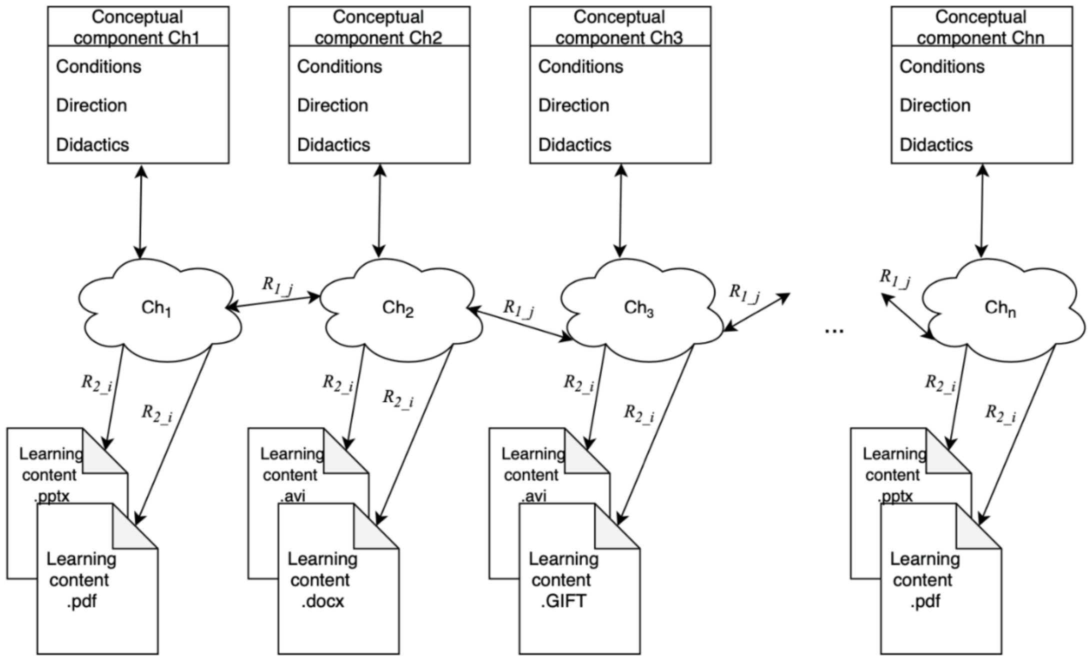


**Figure 1:** The sequence of studying chunks based on the conceptual component with reference to content elements

The set of entities that make up the meaningful ontology of the discipline $O^{Content}$, together with the properties of these objects and the relationship between them, reflect the knowledge of a particular discipline. Also, a content ontology covers the procedural and control-correctional components of the educational process. In turn, with the help of technology for generating test questions [15], which is based on the ontology of the discipline, the teacher conducts control and corrective measures to identify the least mastered chunks.

## 4. Application of interdisciplinary connections of chunks in ontology-based systems

In the learning system, a lot of learning material is interconnected. Therefore, it is impossible to imagine the acquisition of new knowledge without the application of existing ones.

Therefore, it is very important to identify interdisciplinary links [16] and apply them in practice, namely the creation of situations in which the student must realize the importance of acquiring knowledge for their further application, identifying weaknesses of students in previously studied material, and as a consequence individual learning trajectory considering the skills, characteristics and desires of the student.

For example, the didactic ontology of the discipline “Linear Algebra” on the topic “Vector Algebra” will include such chunks as “Vectors’, “Coordinate System” and others. In turn, the didactic ontology of the discipline “Computer Graphics and Multimedia”, the topic “Vector and raster graphics” also contains chunks “Vectors” and “Coordinate System”.

This example is clearly shown in Fig.2. An example of implementation of the procedural component in the study of the topic “Vector Algebra” is offered. In order for the student to realize the importance of mathematical disciplines for a modern programmer or graphic designer, an ontology-based system based on interdisciplinary connections offers applied situational tasks and tasks, during which students consider options for implementing the acquired knowledge in further professional activities. For example, the student must understand and argue his point of view on the application of coordinate system transformations for “Computer Graphics”.

On the other hand, if a student cannot successfully pass the test in the discipline “Computer Graphics and Multimedia”, then due to the didactic ontology it will be clear that the student has not mastered certain chunks, and therefore he should be recommended to repeat not only lectures on vector graphics, but also certain lectures on vector algebra.

## 5. The results of technology implementation

Approbation of the creating educational environment based on ontology-based approach to e-learning systems was carried out on study groups of students of the specialty “Applied Mathematics” KPI. Igor Sikorsky and students majoring in “Psychology” (“Practical Psychology”) NPU. Mykhailo Drahomanov in 2019-2020. The efficiency and efficiency of the developed ontology-based approach to e-learning system is confirmed by the results of practical implementation.

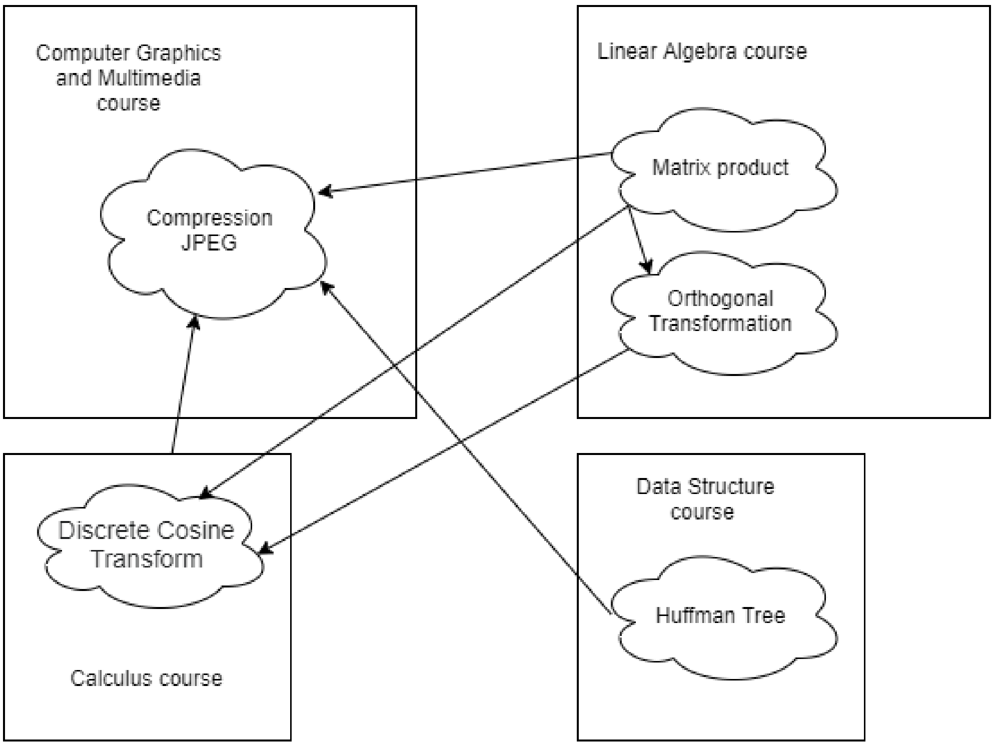


**Figure 2:** Interdisciplinary connection of disciplines “Computer Graphics and Multimedia”, “Linear Algebra”, “Calculus”, “Data Structure” on certain chunks

The experiment was conducted on the basis of four disciplines: “Computer Graphics and Multimedia”, “Linear Algebra”, “Calculus”, “Data Structure”, “Consultative Psychology”.

Due to the situation related to the COVID-2019 virus, the training took place on a mixed system. That is, the first semester classes were full-time.

In the second semester, classes were held remotely, using technology based on a chunk-oriented approach to learning, which also includes lectures, practical, laboratory classes and modular tests throughout the course and credit or exam at the end of the course by means of e-learning systems, including Moodle.

An example of integration of ontology driven e-learning system into existing e-learning systems, on the example of an e-course created with the help of developed tools, is presented in Fig. 3.

On the web-page of each student, the educational content is distributed by modules and topics of the discipline and is presented in several formats. The student independently chooses a convenient time for processing materials and format.

In the process of mastering the material for each discipline, the teacher has the opportunity to view in the e-learning system information about students and protocols of their actions (logs) in the module of analysis of results. In this way, the teacher will know who is an active user of the system, and who came only to pass the control.

The objectives of the experiment were: determining the numerical evaluation of the effectiveness of the traditional approach and the chunk-oriented approach to learning when monitoring the knowledge of traditional control and e-learning system; comparison of the traditional approach and the chunk-based approach to learning.

Parameters for evaluating the effectiveness of test questions and tests: time spent on the test or test (t, minutes); the percentage of correct answers (p,%).

The purpose of the experiment was to prove or disprove the hypothesis of the effectiveness of the integration of the chunk-based approach to learning, as well as to study the rationality of using algorithms for creating test tasks and tests.

In the 2019-2020 academic year, 13 tests were conducted: 7 in the discipline "Algebra and Geometry"; 3 in the discipline "Algorithms and data structures"; 3 in the discipline "Computational Geometry and Computer Graphics".

Each test work consisted of questions that were generated using the developed tool. During the 1st semester of the 1st year, 3 tests in the discipline "Algebra and Geometry" were conducted for the control and experimental groups, and 4 in the 2nd semester. In fig. 4 shows the results of groups A and B of 7 tests, as well as the result and general statistics

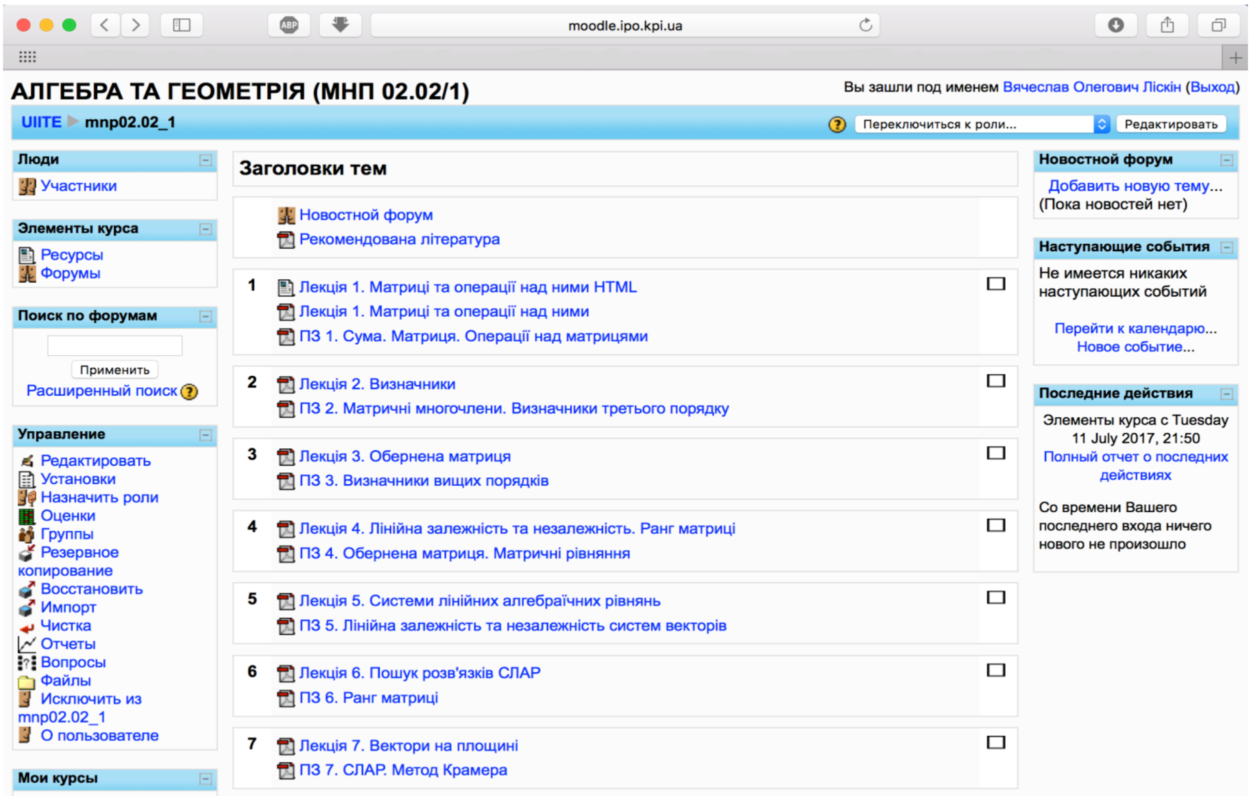


**Figure 3:** Integration of ODELS with the system "Moodle" on the example of the discipline "Algebra and Geometry"

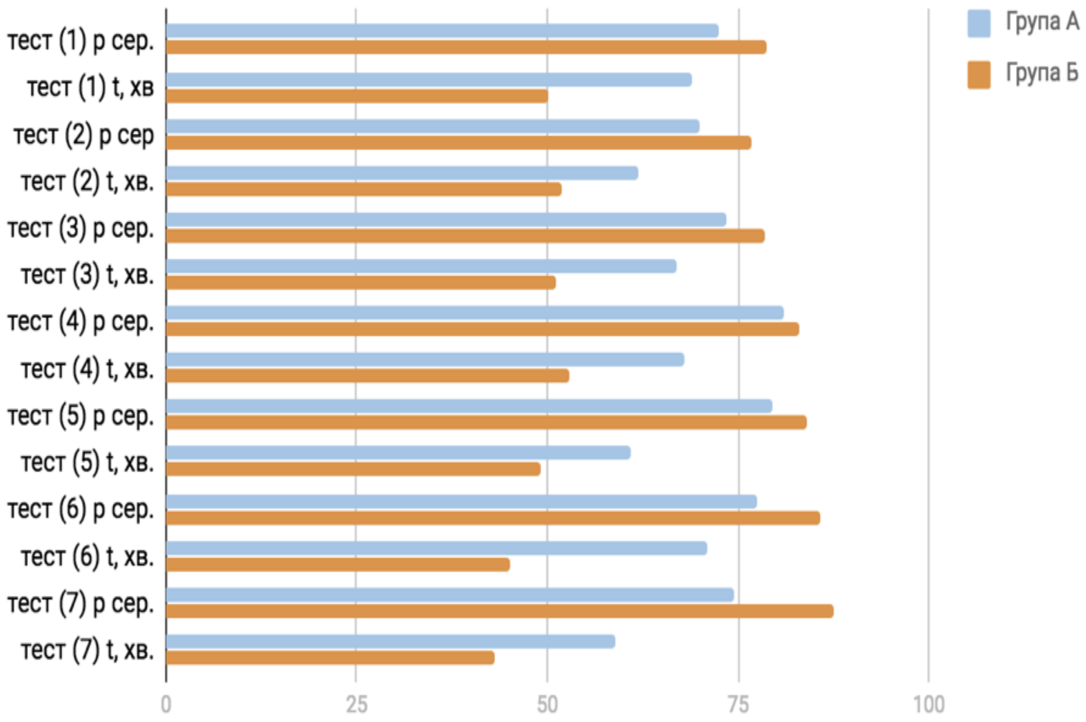


**Figure 4:** Diagram of test results in the discipline "Algebra and Geometry"

At first glance, on figure 4 it can be seen that since the beginning of the experiment the average score of group B increased and the time of work decreased, at the same time both of these indicators in group A changed without visible patterns, indicating possible cases of dishonest attitude to learning or deterioration of overall success in group, which can be caused by many factors.

After analyzing the data shown on figure 4 and calculating the average level of achievement on tests and the average time of work, we can conclude that from the discipline "Algebra and Geometry" the average percentage of correct answers in group B is 7% higher than the result of group A, and the time of work in group B is less than group A for 16 minutes.

Figure 5 presents the results of assessing students' knowledge in three study groups of students of the specialty "Applied Mathematics" discipline "Computer Graphics and Multimedia", respectively.

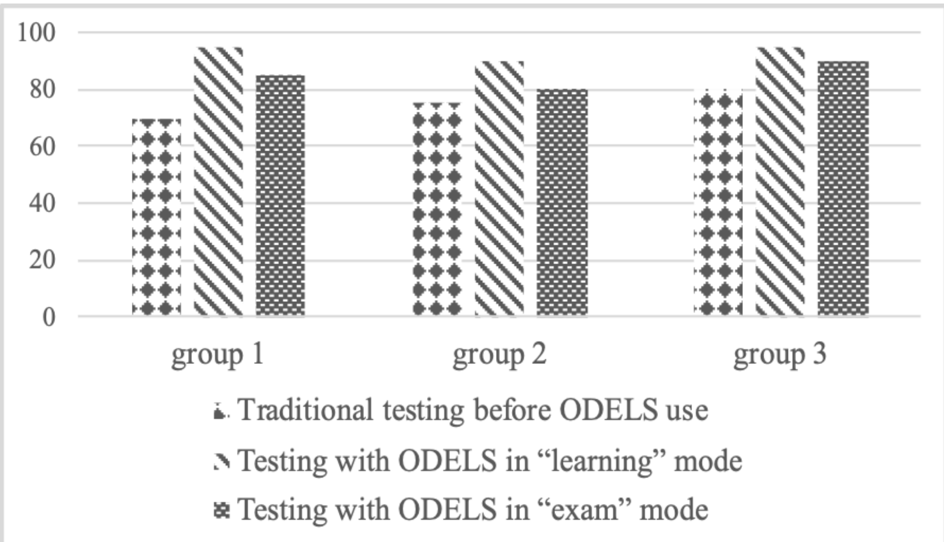


**Figure 5:** The results of assessing students' knowledge in the discipline "Computer Graphics and Multimedia", respectively.

As seen on figure 5, vertical axis gives shows an average mark of the group and horizontal axe shows groups. During repeated traditional testing after application of ODELS students have also increased their level of knowledge by at least 8% as compared to initial testing.

During analysis of the acquired testing results, we have determined that students which were proposed to undergo testing assisted by ODELS dealt with the tasks at hand with more success due to learning while working on tests. Additionally, during result analysis students that underwent level of knowledge control assisted by ODELS were easier to indicate blank spots thanks to use chunk.

Traditionally, while evaluating test results, any points assign for correct replies are summarized, while in the case of using chunk, points for correct replies are annulled if s student replies incorrectly to another question with the same chunk. Such a technique allows us to rule out the possibility of a positive mark in cases of random answer guessing. During evaluation of testing results, an entry threshold is established for each chunk group, which represents course sections.

The analysis of methods of work with test questions showed that in case of small volume of bank of questions (to 30 questions on each section) it is expedient to use tests only for the final control in an examination mode. Given that with each attempt, the sequence of questions and the number of correct answers to the test is different, we can expect that each student has his own version of the test, and will answer independently. Such an approach to student knowledge evaluation allows detecting of weaker points (topics) for the individual student, provide him with recommendations for repeated learning of certain sections of the discipline in the e-learning system, and stimulate him to acquiring deeper knowledge.

With the help of ODELS, students have a holistic view of the subject area and automated control is used to diagnose and monitor the effectiveness of its use. The developed information system based on ontologies allows to identify unscrupulous students, which brings e-learning and distance education to a new quality level. Analysis of the answers to the test questions in comparison with the oral conversation showed that the most effective for solving this problem are situational tests. That is, questions ask the student a certain situation and suggest solutions.

## 6. Conclusion

The technology described above and the possibilities of its application in the process of e-learning will help each student to become cognitively active, real and creative thinking, self-critical personality, to apply knowledge in practice, creating a simulated professional environment.

The results of the application of the developed ontology-based e-learning system and the created bank of test questions in teaching three distance courses showed that the success of learning and mastering knowledge, skills and abilities of disciplines improved by an average of 8% compared to the first semester.

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