

Use of E-resources of the Learning Environment in Teaching Mathematics to Future Engineers

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The urgency of the issue discussed in this article is determined by fact that the modern education model aims at forming a competitive and creative personality of a student striving for continuous self-improvement and self-development. It should be emphasized that mathematical training is an integral part of engineering education. In this regard, the article aims to dwell upon the use of electronic resources of the learning environment in teaching mathematics to future engineers. The leading research method is the student-activity approach which allows to describe the issue in terms of dialogueness, subjectivity and individuality. The article describes the following resources of e-learning environment: motivational-adaptive, subjective, integrative, and managerial. The article reveals pedagogical opportunities of e-learning environment in teaching mathematics to future engineers. The use of electronic media in teaching future engineers at universities is proved to be successful. The materials of this article may be of interest for teachers of higher education institutions.

Keywords: mathematics training, e-learning environment of university, future engineers

INTRODUCTION

Urgency of the problem

The problem of improving vocational education is particularly important in the context of development-orientated policy of Russia. Engineering education has become one of the key factors in the state competitiveness and is the basis for its technological and economic independence. The widespread use of information and communication technologies in various spheres of modern society led to the necessity to upgrade methods and forms of training competitive professionals. Mathematics training is of key importance in professional development of future

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engineers because mathematical disciplines ensure the formation of students' readiness for professional work as they are characterized by inter-subject communication and strict cause-and-effect relations, evidence and validity of scientific statements and theories, experimental proof of ideas, quantitative and qualitative language of description of reality models.

Status of the problem

The future engineers must have a basic knowledge of mathematics and natural sciences; be ready to apply the basic laws of physics and chemistry in their professional activities; apply methods of mathematical analysis and modeling, theoretical and experimental research; identify the essence of the problems which arise in the course of professional activities, and have an ability to use the physical and mathematical instruments to solve the problems (Yachina et al, 2016; Kamalova & Zakirova, 2015; Mokeyeva, Zakirova & Masalimova, 2015; Zakirova & Koletvinova, 2014; Zaitseva, 2013).

This approach requires explaining the unity of mathematics training in the system of engineering education at university. The above is determined by the following ideas. Firstly, inter-subject communication between mathematical and natural sciences leads to the process of mathematization of science. Secondly, mastering the content of mathematical sciences is an integral part of continuous training of future engineers. Thirdly, computerization and electronization of professional engineering activities determine the necessity of relevant competencies, formed in the course of mathematics training (Gabdrakhmanova et al, 2015; Sibgatova et al., 2015; Muravyeva et al., 2014; Sibgatova et al., 2016).

The above allows us to work out a unified position on the nature of mathematics training. In particular, we are interested in the procedure aspect – in defining the stages of mathematics training of future engineers at a higher education institution. Following A. S. Voronin (2006), we understand mathematics training as formation of motivation, knowledge and skills necessary for an individual to adequately perform specific tasks. Following the idea of E.F. Zeer (2010) about the phases in the vocational training, we distinguish the following stages of mathematics training of engineers at a university: adaptation, intensification, identification. Below we will describe the essence of each stage in more detail.

Actualization of knowledge and abilities of students is the key element of the first stage of training, which should take into account personal qualities and characteristics of future engineers. This approach allows us to not only individualize and differentiate the process of teaching engineers, but also provides successful adaptation of students to the higher education environment. The purpose of the next stage of mathematics training at university is characterized by the process of structuring and systematizing students' knowledge and skills by means of modern educational technologies. The use of information and communication technologies contributes to activation of learning and cognitive activity of students providing quick feedback, availability of varied techniques and training methods, ensuring intensification of the process of mathematics training at university.

Using practice-oriented tasks related to future professional engineering activity in combination with various forms of training and learning activities at the third stage of mathematics training at university characterizes the stage of identification (Valeeva & Shakirova, 2015).

The above stated ideas are crucial to our research and determine further presentation of the materials of the research.

We have identified the reasons explaining the significance of mathematical preparation of students in the professional training of future engineers; its key

features and principles have been described; the current problems existing in practice of teaching mathematical sciences have been identified.

Below each of these aspects is considered in more detail.

Significance of mathematics training in the professional education of engineers

The analysis of legal documents, analytical, psychological and educational research literature allows to identify the reasons that determine the significance of mathematics training in professional education of engineers.

Firstly, entrance (profile) examinations in the areas of training which are included in the program of "Engineering, technology, engineering science" education, are held in mathematical sciences; secondly, mathematical sciences should be learnt prior to professional subjects. This fact explains the urgency of the research and requires the search and development of mechanisms aimed at improving mathematics training.

Another reason, which determines the attention to mathematics training of future engineers at university, is methodological potential and possibilities in respect of professional education of future engineers.

Taking into account the above characteristics and the specific character of the future work of engineers, we have identified three key approaches to defining the functions of mathematics training of engineers at university.

According to the first approach, mathematics is considered to be an independent science and it reveals its methodological potential. Myshkis (2003), Plotnikova (2010) and others are sure that learning this science contributes to development of analytical and logical thinking, formation of spatial concepts, imagination, algorithmic culture, formation of abilities to establish cause-and-effect connections, to justify one's claims, to model a situation, to develop intellectual abilities.

According to this approach, the aim of studying mathematics is to nurture methodological culture of cognitive knowledge of the future professional. The latter is determined by the following knowledge: structure of activity, mathematical models, logical relationships of need-sufficiency, structure of programming languages. This knowledge is at the essence of the thinking process aimed at transforming conceptual models into the structural-functional object of study. Consequently, it is an integral part of professional (intellectual, operational and creative) activities of future engineers.

Thus, mathematics can be considered one of the leading tools of experiencing the surrounding reality in the process of engineering education. This tool forms such scientific methods as an analogy, comparison, analysis, synthesis, generalization, induction, deduction, modeling, and others. This is important, as the methods mentioned constitute the basis for solving professional problems of engineers.

At the same time, we should note that the mathematical sciences are mainly studied in the first and second years of university. According to scientists, formation of methodological culture of cognitive knowledge is not completed at this stage yet. In this context it seems appropriate to consider the cognitive function of mathematics training of future engineers.

The second approach, which determines the functional use of mathematics, is conditioned by its application capacities and the possibility to use mathematical tools to solve the problems of natural sciences. This view is the result of the analysis of various scientific ideas.

The researchers believe that the applied character of mathematics is realized by means of including mathematics in the system of preparation of the set of application tasks, the content of which reflects the specific character of the future

professional activity. Thus, students perceive mathematics not as an abstract science irrelevant to their future professional activity, but they get aware of its importance for future professional activities.

G. Mikhailova (1998) describes how this approach is implemented: development and solution of applied tasks in accordance with the specific character of their future professional activity, application of the method of mathematical modeling, the use of technical training aids, etc. The above ideas are important for our research and are further reflected below in the article.

The essence of the third approach is integration of the ideas of the first and second approaches. The generalized idea on this approach can be the view of Khinchin (1963). Considering the tasks of teaching mathematics at university, he talks about their bi-directional character which is characterized by the desire to master the mathematics techniques as an instrument of acquiring knowledge and teaching the future specialist to practise mathematical calculations. As a condition to achieve this goal the author identifies a possibility of each new theoretical idea to be connected "with the practical calculations associated with it" (Khinchin, 1963)

Studying the functional characteristics of mathematics in the process of training future engineers, he argues that the two approaches described above are interdependent and complement each other. In particular, the purpose of mathematics is determined in two ways: as a goal and as a means.

Thus, sharing these opinions, we arrive at a conclusion that mathematics training in the professional education of future engineers performs cognitive, applied and integrative functions. On the one hand, it is the methodological basis of the system of training, and, on the other hand, it prepares a student to use mathematical knowledge while learning professional subjects.

Taking the above and the specific character of the future professional activity in consideration, we define the cognitive, applied and integrative functions of mathematical training of engineers at university as the key ones.

These functions of mathematical training of engineers are associated with the implementation of specific and general didactic principles of training: fundamental nature, practical orientation, informational support, eco-balance and economization.

A cluster of mathematical competencies as a result of mathematical training of engineers at university

Having analyzed the Federal State Education Standards, university curricula, competency matrices, steering documents, we understand the result of mathematics training as a cluster of competencies, including motivation, cognitive-activity and self-reflection components.

The motivation component is characterized by value orientations, motives and interests of future engineers aimed at learning mathematical sciences. It reveals the students' own willingness to set and achieve professional goals, as well as to improve their knowledge, skills and abilities.

The cognitive-activity component is characterized by theoretical and practical knowledge generated by students in the course of mathematics training, the ability to identify scientific and mathematical nature of the problem situation, the ability to analyze the result, to make an assessment of and predict possible effects, the ability to correctly and reasonably express their views on mathematics and science issues. A well-formed cognitive-activity component is characterized by skills of solving practice-oriented tasks, knowledge of methods of mathematical analysis and modeling, theoretical and experimental research.

The self-reflection component is characterized by abilities which allow to consciously evaluate the process and the result of knowledge acquisition and

reproduction of certain actions and to carry out activities aimed at self-regulation and self-management.

The above stated allows us to define mathematics training of future engineers as a purposeful process supported technologically and methodically, and characterized by the consistent implementation of the stages of adaptation, intensification, and identification; it is aimed at developing the cluster of mathematical and science competencies, and structured in accordance with the motivation, cognitive-activity, and self-reflection components.

The existing problems in mathematics training of future engineers at university determine the necessity of finding new ways and approaches to its improvement. By "improving" we understand the creation of a specific set of conditions or identification of possible resources to modernize the teaching process in order to increase its effectiveness.

Effectiveness in this case is seen as an ability to achieve educational goals. In this context, it is of particular importance to analyze the immediate circle of the subjects of the educational process, understood as their environment. In conformity with the stated views, experts believe that environment organized on the basis of information and communication technologies, distance learning technologies, and e-learning technologies has a great potential.

Specific character of mathematical training of engineers in conditions of e-learning environment of university

The terminological analysis of the categories of "environment", "educational environment", "learning environment", "e-environment" and a number of others derived from them allowed us to prove reasonable the introduction of the pedagogical science concept of "e-learning environment", and to reveal its essence.

The analysis of the phenomenon of e-learning environment is carried out through the analysis of scientific concepts, theoretical aspects of pedagogical science, psychology, cybernetics and informatics. The scientific basis of pedagogical science allows to consider the specific features of the training process in conditions of e-learning environment. Psychological theories and laws make it possible to discover the unique character of the process of interaction of its subjects. Cybernetics concepts are the basis for identifying features of diversified management of the training process. The current level of development of computer science explains its pedagogical value.

We have developed the structure of e-learning environment which includes content, communicative and technological components.

As for the functional characteristics of e-learning environment, we will explore the issue with the view that e-learning environment is a synthesis of electronic environment and learning environment. The electronic environment can be described as a system of facilities (computer machines, hardware and software) which interact on the basis of formal rules (architecture, standards, technical parameters, programming languages, etc.), and processing, storage and transmission of digital information.

According to this approach, the main characteristics of the electronic environment are the following: structural properties, multi-channel character, multimedia, virtual reality, processability, openness. The properties of the learning environment are information value, adaptability and processability.

The main characteristics of the e-learning environment, in our opinion, are structural properties, multi-channel character, multimedia, adaptability, openness, processability, and compensatory character. Let us consider each characteristic in more detail.

The focus of the environment determines the direction of its development, its structure and functions. Having structural properties suggests a well-defined structure of internal components and their interconnection. In this respect the study conducted by G. Yu. Belyaeva (2013) is of interest to us as it reflects a detailed description of the systemic nature of the environment performing educational functions. The author points out the importance of structural properties as the basic ones for creation and functioning of the learning environment.

The efficiency of content and communication components is mainly determined by properties of information value, and multi-channel character (ability to store, perceive and process several information flows at a time).

The multi-media (use of different data formats), and openness properties (ability to make changes in the content, to use varied diagnostics and communication means; an opportunity to enter the world educational space by means of the Internet) lead to the adaptability property which gives students a possibility to choose the optimal pace of learning, the kind of communication between the participants of the educational process, as well as between the subject and the environment.

The compensatory property is optimization of the learning process and its ergonomic characteristics, reducing the time and efforts spent to understand and remember the material. This is largely achieved by means of management of the learning process through the use of algorithms and training materials, implementing properties of adaptability (the abilities to use modern technology to create the learning content, to study, to communicate, to monitor and make diagnosis) and virtual reality (a possibility to perform actions not with real objects, but their simulations).

The structural components mentioned above, as well as the properties of e-learning environment are the basis for defining its basic functions which are the following: informative and training, organizational and motivating, diagnostic and corrective, and communicative managerial.

To summarize the above said, we believe that informatization and electronization of education has led to creation of a new kind of education environment (e-learning environment). The e-learning environment is a system of interconnected components (content, communication, technology) ensuring implementation of informative-training, organizational-motivating, diagnostic-corrective, and communicative-managerial functions in the process of interaction of the subjects of the training process. The e-learning environment has the properties of structure, multi-channel, multi-media, adaptability, openness, adaptability, processability, and compensatory character.

Interaction of the content, communication, and technology components allows to perform the e-learning environment the following functions: informative-training, organizational-motivating, diagnostic-corrective and communicative-managerial.

The informative-training function manifests itself in fast "delivery" of information of both teachers and students, a possibility to work with automated databases. The organizational-motivating function is coordination of the training process, as well as formation of individual educational plans. This allows to take into account individual personality traits of students, and also creates a "situation of success"

The communicative-managerial function is connected with the above ones and it promotes implementation of varied forms of interaction between the subjects in the environment of e-learning; it stimulates continuous feedback and pedagogical support of classroom and extracurricular activities of students.

The diagnostic-corrective function enables to perform an automated diagnosis by means of immediate feedback; to trace changes in various parameters of an

individual educational trajectory: pace, complexity of tasks, level of a student's knowledge.

Resources of the e-learning environment

The pedagogical potential of the e-learning environment in the field of mathematical training of engineers at university is presented with a set of resources: *motivational-adaptive* resources: taking into account psychophysiological qualities and characteristics of students; creating motivating situations (situation of success, elements of competition, and others); creating an atmosphere of cooperation and dialogue interaction;

subjective resources: a right of a student to choose his individual learning trajectory and then modify it; promoting teaching and learning activities by means of professional orientation of training, use of e-learning technologies;

integrative resources: integration of the content of mathematical and natural sciences with elements of professional knowledge based on the common concepts and inter-subject connections; integration of forms and methods of interaction of the participants of the training process;

management resources: fast feedback, continuous educational support of classroom and extracurricular activities of students.

Hypothesis of the research

Analysis of psycho-pedagogical and methodological literature, as well as the experience in the aspect of the issue discussed has shown that the use of electronic media learning resources in teaching mathematics needs to be clarified and further developed. It is primarily explained by the change in the educational paradigm, updating methods, and requirements to the level of knowledge of graduates, etc.

The above allows to formulate the hypothesis of the research: the process of teaching mathematics to future engineers will be more effective if electronic media learning resources are used in the educational process.

MATERIALS AND METHODS

Methods of teaching mathematics to future engineers in the e-learning environment

The e-learning environment can be considered as a factor improving mathematics training of future engineers at university.

To prove this idea we will make a description of the pedagogical potential of the e-learning environment, its resources and capacities to improve mathematical training of future engineers at university.

Given the potential of e-didactic educational environment, it was possible to work out the author's program of teaching mathematical subjects to future engineers ("I want to be an engineer – can you teach me?"). The program is represented by the following modules: "Knowledge-based Puzzle", "Entertaining Modeling", and «Creative Laboratory".

The module "Knowledge-based Puzzle" involves the solution of the following tasks: identifying the level of students' motivation to the study of mathematical sciences and to their future profession; identifying the initial level of mathematical knowledge; identifying the "barrier" mechanisms in the study of mathematics; diagnostics of the degree of self-reflection and self-control skills.

This module aims to develop analytical skills: analyzing information in order to solve practice-oriented tasks; understanding mathematics as a "tool" to describe the

world phenomena and the processes related to future professional activities; techniques and methods to correctly express and give a reasoned justification of one's views; predicting possible consequences; making algorithms of actions related to calculation operations in mathematical subjects.

The information content of the module is represented by: webinars – "I want to be an engineer – can you teach me?"; "Information Crystals" (about effective information processing techniques); "Time Management Secrets"; "Kaleidoscope of Discoveries"; "Cool Mathematics"; chats – "Engineer of the third millennium – what is the engineer of the future?"; "Mathematics (physics, chemistry) for an Engineer: Myths and Reality"; a roundtable discussion – "The Legacy of the Past" (great scientists, inventions and discoveries); and such techniques as cinquain, "Constellation: Engineer", the tree of wishes; five fingers; Fish-born, 'thick' and 'thin' issues.

The module "Entertaining Modeling" trains the students' skills to use the mathematical apparatus to model and study various natural, technological, and social processes; forms students' self-reflexive attitude to studies. To achieve this goal the following classes are held: webinars: "Short Circuit," "How to distinguish a lie from the truth? (solution of logical problems)"; "Ups and Downs"; counseling forums and discussion forums: "Exact Sciences: Algorithm or Creativity?"; "Standard and Non-standard Tasks"; and the following techniques are used: mixed logic chain; 'thick' and 'thin' issues; cross-discussion, etc.

The use of e-resources (motivational-adaptive, subjective, interactive, managerial) of the learning environment ensures effective interaction of the participants of the training process and contributes to the formation of the cluster of competencies structured in accordance with the motivation, cognitive-activity, and self-reflection components.

The purpose of the third module "Creative Laboratory" is development of imagination and systematic thinking; shaping the skills to forecast operation capacity of technical systems. Motivation of the learning and cognitive activity of students is done by means of mathematical preparation of e-learning technologies, solving open-type tasks and modeling the processes of animate and inanimate nature. The module offers the following webinars, "Constellation of Mathematics and Natural Sciences", "Visiting Natural Sciences"; virtual tours; counseling forums and discussion forums: "Exact Sciences: Algorithm or Creativity?"; "Standard and Non-standard Tasks"; and a chat "Gallery of Inventions", etc.

The students' right to determine their own educational trajectory, integration of forms and methods of interaction of the participants of the training process, a continuous educational support of students' classroom and extracurricular activities allowed us to improve the process of mathematics training of future engineers at university and to create a favorable atmosphere of interaction between the teachers and students.

The developed training program meets the requirements to mathematical education of engineers at university and allows to realize the maximum potential of e-learning educational environment. The results of the study prove that the implementation of the training program in conditions of e-learning environment ensures the efficiency of mathematics training of future engineers at a higher education institution.

RESULTS

Description of the experiment

The experiment was conducted at the premises of the following educational institutions: the Vyatka State University and the Moscow State Industrial University

(Kirov branch). Experience of mathematical training of engineers at the Vyatka State Agricultural Academy has also been studied and analyzed. The participants of the experiment were students of electro-technical, chemical and automotive engineering departments (429 people), professors of mathematical sciences, qualified experts of the e-learning department of the Vyatka State University.

Effectiveness of the experimental work was assessed with the following parameters: the degree of the motivation component; the level of formation of cognitive-activity component; the level of formation of the self-reflection component. The analysis was made in the framework of the cluster of competencies described above.

At the diagnose stage of the experiment the majority of students showed a low or average level of formation of motivation, cognitive-activity, and self-reflection components (Table 1).

At the formation stage of the experiment we introduced and ran a model of e-learning environment in order to improve mathematics training of future engineers at university; the author's program of teaching mathematical sciences to students in the conditions of e-learning environment was tested.

Results of the experiment

Table 1 demonstrates the level of formation of motivation, cognitive-activity, and self-reflection components of students' cluster of competencies (experimental group and control group).

At the control stage of the experiment diagnostic techniques revealed students' increasing interest and awareness of the importance of mathematical disciplines for future professional activities. In particular, the decline in the number of students with a low level from 36.3% to 18.6% and the increase in the number of students having average (from 48% to 59.3%) and high (15.7% to 22.1%) levels of formation of the motivation component.

The positive dynamics in the formation of competencies of the mathematical content is achieved by means of integration of mathematical knowledge with professional knowledge based on the common concepts being studied, intersubject connections; integration of methods, forms and means of education.

In addition, fast feedback and continuous educational support of students' classroom and extracurricular activities resulted in the increase in the number of students with high (from 16.2% to 27.9%) and average (33.3% to 45.6%) level of development of cognitive-activity component, and reduction in the number of students having a low (50.5% and 26.5%) level.

Table 1. The level of formation of motivation, cognitive-activity, and self-reflection components at different stages of the experiment

		Experimental group -204	Motivation component			Cognitive-activity component			Self-reflection component		
		Control group -225	low	medium	high	low	medium	high	low	medium	high
diagnose stage	Experimental group	students	74	98	32	103	68	33	61	94	49
		%	36,3	48	15,7	50,5	33,3	16,2	29,9	46,1	24
	Control group	students	86	109	30	96	84	45	74	113	38
		%	38,2	48,4	13,4	42,7	37,3	20	32,9	50,2	16,9
final stage	Experimental group	students	38	121	45	54	93	57	40	103	61
		%	18,6	59,3	22,1	26,5	45,6	27,9	19,6	50,5	29,9
	Control group	students	67	122	36	83	92	50	66	109	50
		%	29,8	54,2	16	36,9	40,9	22,2	29,3	48,4	22,3

As for the level of formation of the self-reflection abilities at the diagnose and control stages of the experiment, we also see its positive dynamics, namely, a decrease in the number of students with a low level (29.9% to 19.6%) and an increase in the number of students with average (46.1% to 50.5%) and high levels of self-reflection component (24% to 29.9%).

The experimental data shows significant differences in the percentage share of students with medium and high level of formation of motivation, cognitive-activity, and self-reflection components in the experimental and control groups.

The qualitative and quantitative evaluation of the results showed that the experiment aimed at improvement of mathematics training of engineers in the e-learning environment of university created the conditions for the positive dynamics of the level of formation of motivation, cognitive-activity, and self-reflection components of the described cluster of competencies; the implementation of the training program allowed to carry out this process in the most effective way (Figure 1).

CONCLUSION

The results of the study make it possible for us to conclude that the goal has been achieved, the set tasks have been solved; the theoretical and experimental data of the experiment support the hypothesis and lead to the following conclusions.

The study has scientifically justified the essence of mathematics training of future engineers at university, which we define as a purposeful, technologically and methodically supported process characterized by consistent implementation of the following stages: adaptation, intensification, and identification aimed at developing the cluster of competencies of mathematics and science content.

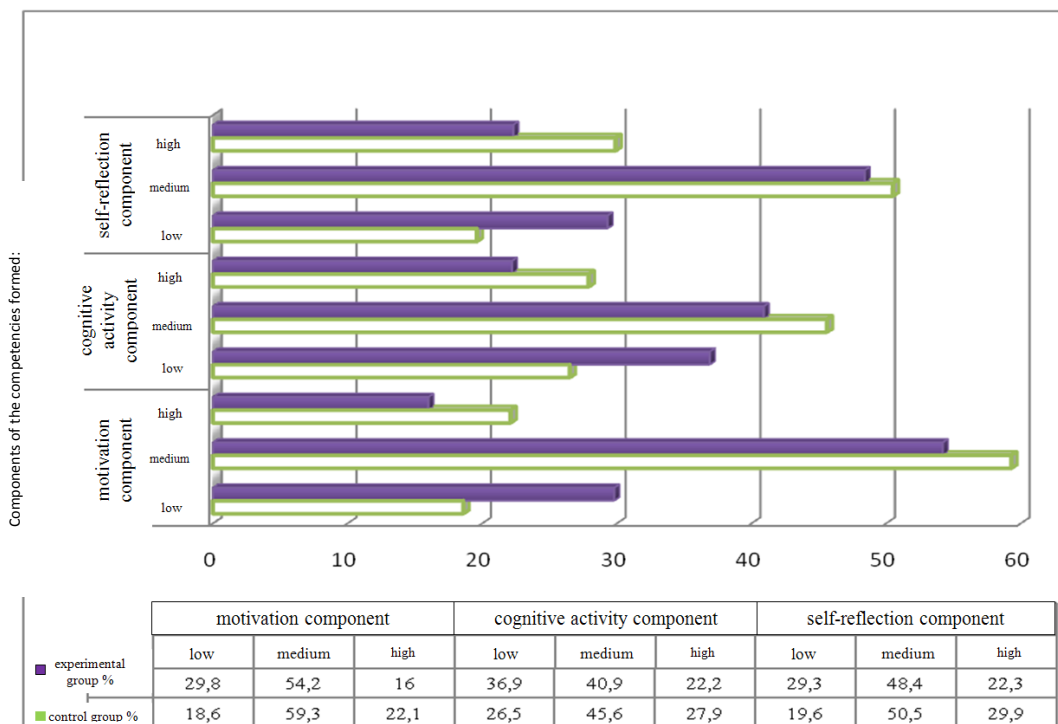


Figure 1. The level of formation of motivation, cognitive-activity, and self-reflection components at the final stage of the experiment

The e-learning environment is understood as a factor of improvement of mathematical training of future engineers at university, it is characterized by interconnected components (content, communication, technological), and ensures the performance of organizational-stimulating, informative-training, diagnostic-corrective and communicative-managerial functions in the interaction of the subjects of training while mastering educational programs.

The pedagogical potential of the e-learning environment presented as a set of motivational and adaptive, subjective, integrative, and managerial resources helps to improve mathematics training of future engineers at university.

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