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# Training of Engineers in Mathematics at University on the Basis of the Information Cybernetic Approach

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**ABSTRACT**

The relevance of the presented research is conditioned by the necessity of continuous formation of a competitive personality. The competitiveness of the state in the world market is caused by the level of transport and energy infrastructure, the level of training and qualification of the country's engineers. These have determined the task currently being decided by educational organizations to find new resources for training of highly qualified specialists for the diverse industries to develop. Analyzing the multicomponent training of future engineers, experts note the pedagogical potential of mathematical disciplines in the formation of professional competence of engineers. The potential of the cyber-information approach in the training of engineers at university is disclosed and justified in the article, the potential is represented by a combination of the following resources: motivational-adaptive, subjective, integrative, managerial. The authors developed the author's method of training of future engineers in mathematics at university on the basis of the information-cybernetic approach, represented by successively implemented modules: "I get to know myself." "Intellectual puzzle", "Entertaining modeling", "Creative laboratory". The effectiveness of the developed methodology was proved in the course of the experimental research carried out from 2012 to the present time and the experimental training in mathematics at university using the didactic potential of the information cybernetic approach. The materials of the article can be useful in practical terms for university teachers of mathematics striving to significantly improve the level of mathematical training of future engineers.

**Keywords:** training of students in mathematics at university, information-cybernetic approach, subject-subject interaction

## INTRODUCTION

### Relevance of research

In the conditions of modernization of the socio-economic sector of the country, the problem of improving the training of future engineers is becoming more urgent and requires a deep rethinking, both at the theoretical and practical levels. This is due not only to the complication of technology and the development of new technologies, but also to changes in the structure of engineering and technical activities and the tasks to be performed. In this regard, the requirements for the level of training of engineers are increasing.


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**State of the literature**

- In the educational paradigm of Life Long Learning, blended-learning has become widely accepted, suggesting the optimal combination of full-time and distance (remote) forms of interaction between teachers and students. At the same time, this aspect is not fully described in pedagogical and methodological studies on mathematics education.
- The use of modern information and communication technologies in training of future engineers in mathematics at university is not fully explored in the literature on the theory and methodology of teaching mathematics.
- The majority of studies on mathematical education note the contradiction between the need of modern society in the training of competitive engineers and the level of mathematical training of future engineers at university.

**Contribution of this paper to the literature**

- A mathematical course of interdisciplinary content "Mathematics in Natural Science" is proposed for the basic school students of the 7th - 9th grades in additional to mathematical education based on the material revealing the interrelationship between mathematics and natural sciences. It is demonstrated here how the results obtained in mathematics, served as a source of new ideas and results in individual sections of the natural sciences.
- For the first time, both individual open-type tasks and their systems are introduced to the course. By solving them, a student is involved in universal educational activity (goal-setting, planning, argumentation, analysis, synthesis, comparison, control, and self-control) and consequently achieves meta-subject results.
- In addition to mathematical problems and open-type tasks, project technologies aimed at achieving the result of inter-subject activities are widely used that was practically excluded earlier in the traditional method of teaching mathematics.

The image of the engineer of the twenty-first century consists of such components as professional competence, confidence, ability to work in a team, readiness to take and implement sound decisions in a professional manner, etc.

This approach requires a qualitative revision and improvement of both content and technological components of the training system of future engineers. Without a serious improvement in the quality of engineering and technical education and the social potential of engineers, improving the structure of engineering training, it is impossible to carry out more rapid and intensive scientific and technical progress, large-scale introduction and mastery of new technologies (Gok, 2014; Leong, 2014**;** Sahin & Adiguzel, 2014; Gabdrakhmanova, Khuziakhmetov & Yesnazarova, 2015; Iqbal & Saleem, 2016).

Implementation of the presented idea becomes possible if the process of training future engineers in mathematics at university is modeled on the basis of the information-cybernetic approach. First of all, this is due to the wide spread and introduction of e-learning into the educational practice. This methodological basis is a synthesis of the main points of the information and cybernetic approach. Let us consider the specifics of each in detail in the context of the problem being investigated. In a broad sense, the essence of the information approach is determined by an abstract generalized description, and the study of the information aspect of functioning, structure and interaction of complex systems. Scientists emphasize the close connection of the approach in question with the ideas of the system and activity approaches. This position is explained by the following factors. Firstly, the information approach is based on a general theory of systems and is aimed at studying the information interaction between systems. Secondly, information as a measure of the organization of the system is inseparable from it (the system cannot be uninformative). Thirdly, any activity assumes information support and is based on the transformation of available information. In a narrower sense, the essence of the information approach can be defined through the construction of the "ultimately abstract model of information reality, a system of information-

theoretical knowledge, generalized at the level of principles." (Andreev, 2011; Afanas'yev, 1980; Khutorskoy, 2010; and others).

The possibility of studying the system as a device for processing information is very valuable, because it provides its representation through subsystems that perceive, transmit and process information in accordance with their functions in the general process.

Thus, the ideas of the information approach allow us to identify and analyze information links both between the components of training future engineers in mathematics at university, and between elements of the information and educational environment. The presence of information flows between the elements of the system imposes a number of requirements: flexibility, manageability, organization and content. In this regard, it is essential to consider such a methodological basis as the cybernetic approach.

Theoretical prerequisites for its development were the principles of self-organization of intellectual systems, the ideas of neurolinguistic programming, cognitive psychology and management theory. Applied to educational practice, its essence is revealed in the works of A. A. Andreev (2011), V. P. Bespal'ko (1996), I. V. Krasilnikova (2009), I. V. Robert (2011), and others. In pedagogy this approach has spread through the development of programmed education and the use of automated training programs. This approach allows us to present and model the process of interaction between the teacher and the student through the computer, as well as the use of distance learning technologies and e-learning technologies; to seperate management as one of the leading types of the activity of subjects of the learning process. In this case, the managing system is the teacher or the training program and the managed system is the student. The analysis of psychological and educational literature allowed to identify two key ideas of the cybernetic approach in the aspect of improving the training of engineers in mathematics.

The idea of a functional variety determines the functions of subsystems, in particular, their managerial aspect. It sould be noted that the functional set of the managing system must be wider than the set of functions of the managed system. This is because the management will be effective only when the teacher and/or the training program will be able to respond to all possible options for the student's actions. In this case, the functions of the management system include: information representation, error correction, performance evaluation, stimulation (creating a success situation) of the managed system, providing feedback. All these, in turn, must provide a managing effect. The main functions of the managed system are the perception and processing of information, the implementation of exercises, assignments, consideration of corrective measures and their implementation, monitoring and ensuring the movement along an individual educational path.

This approach creates a favorable emotional background, increases the activity of the student, implements feedback in training, thereby ensuring the efficiency and predictability of the process of training of future engineers in mathematics at the university. It should be noted that it is possible only if management objectives, management methods, implementation of the direct and feedback channels are clearly stated and defined.

The presence of feedback, as noted above, is the basis for the quality management of the learning process. It is through the feedback channel that information about the state of the managed system is transmitted. Thus, favorable conditions are created for the teacher to exercise the management and correct actions and for the student to better learn the information. Summarizing and relying on the studies of R. V. Mayer (Mayer, 2001), we formulate the basic positions of the information cybernetic approach in modeling the training of future engineers in mathematics at university: the analysis of the pedagogical system from the viewpoint of the theory of management and interaction of information flows; improvement and optimization of the learning process (methods, forms, technologies) in order to improve its effectiveness through the use of technical means, training systems, etc.; the management of the learning process through the implementation of feedback between the subjects; development of the appropriate content aimed at improving mathematical training.

This was the main idea for the development of the stages of the methodology for training engineers in mathematics at university. Understanding the methodology as an algorithm for constructing and implementing an activity has guided us to the process of detailing, the isolation of "steps" in the organization of training in

mathematics at university on the basis of the information-cybernetic approach. We have identified the following stages: "I get to know myself", "Intellectual puzzle", "Entertaining modeling", "Creative laboratory".

These stages are correlated with the future professional activity of the engineer and reflect the integrity of the process of mathematical training at university. We believe that this sequence contributes to improving the mathematical training at a university on the basis of the information-cybernetic approach. It should be emphasized that each stage has a certain potential for forming the competencies of the future engineer.

## Focus of the research

The aim of this article is to develop a methodology for training of engineers in mathematics at university on the basis of the information-cybernetic approach. The formation of students' positive motivation study mathematical disciplines, the formation of algorithms related to computational and computing operations in mathematical disciplines, the development of imagination and system thinking, formation of skills for forecasting the development of technical systems, research and reflexive skills have been defined as the main aims.

# LITERATURE REVIEW

## Analysis of Russian scientific and pedagogical literature

L. R. Zagitova (2014), L. V. Medvedeva (2001), etc. write about the problems of training of engineers in mathematics. The authors focus on the complex and systematic training of future engineers in mathematics and offer the implementation of the following principles: continuity, interactivity, manufacturability, aimed at improving mathematical training.

The problems of improving the professional training of engineers are discussed in the researches of E. V. Maikov (2006), N. I. Naumkin (2006), and others. Technological mechanisms and methods of training of future engineers are pointed in their works. Attention is drawn to the phenomenon of synergism of pedagogical influence, which is interpreted as the result of the combined action of its components.

Training methods with the use of information technologies and the cybernetic management cycle are considered in the works of D. N. Monakhov (2013), A. V. Solovov (2006), etc. The authors prove that they provide effective interaction between all participants of the educational process and the students' mastery of training programs through the structural property, the properties of multi-channel, multimedia, adaptability, openness, manufacturability, compensatory.

M. A. Akhmetov (2009), T. Grebenyuk (2009), S. I. Osipova (2013), I. E. Unt (1990) investigate the problems of individualization and differentiation of training, which, in the authors' opinions are key in the implementation of the information-cybernetic approach in training in mathematics.

## Analysis of foreign studies

It is necessary to note the high degree of development of the problem of training in mathematics and use of ideas from the information and cybernetic approach in educational practice.

The problem of training in mathematics is explored by I. Budak & B. Kaygin (2015). The authors describe in detail the structure of the process of training in mathematics in the learning environment, paying attention to its motivational, cognitive-activity and reflective components. In particular, special attention is paid to the study of mathematically promising cognitive abilities of students and the mechanisms of their development.

Methodological aspects of designing and using the system of tasks in the training practice are investigated by M. Henningsen & M. K. Stein (1997). They revealed the basic principles of constructing the system of tasks that ensures continuity between all levels of education, as well as the potential of a learning task in mathematics that allows to form a positive motivation for learning, to develop the cognitive and reflective spheres of students; to activate educational and cognitive activity.

The influence of computerization on the learning process is studied by the foreign scholars M. Dunleavy, C. Dede & R. Mitchell (2009), J. Martín-Gutiérrez, C. E. Mora, B. Añorbe-Díaz & A. González-Marrero (2017). They explored the possibilities of a virtual educational environment in the management of the cognitive activity of the subjects of the learning process. In addition, the effectiveness of using information technologies in creating the modern educational model has been justified and proven.

M. Dunleavy, S. Dede & R. Mitchell (2009) proposed to develop modern learning scenarios (subject-interactive medium-subject) on the basis of a complex of information technology capabilities. In particular, the works present the experience of implementing a learning model based on cognitive and practical methods aimed at improving both educational and technological processes.

So, the analysis of the Russian scientific and pedagogical literature and the foreign studies allowed us to conclude that the problem of training of engineers in mathematics based on the use of the information-cybernetic approach is relevant and connected with the ideas of implementing the principles of complexity, practical orientation, and systematicity.

## MATERIALS AND METHODS

### Methods of research

The following methods have been used to carry out the research: analysis of psychological, pedagogical, mathematical and methodical literature on the topic of the research, analysis and generalization of the experience of teachers of mathematical disciplines and our own experience in giving lessons, analysis of the products of students' learning activities, forecasting, systematization and generalization of facts and concepts, modeling, design, analysis of the results of educational activities, diagnostic techniques, pedagogical experiment.

### Experimental research base

Approbation, generalization and implementation of research results are carried out:

- by carrying out pilot training of future engineers in mathematics in educational organizations of Kirov.
- in the form of reports and speeches at scientific conferences and seminars of various levels, including international ones, publications of scientific articles.

### Stages of research

The study was conducted in three stages:

First of all, a review of philosophical, psychological, pedagogical and methodical literature on the research problem has been carried out; the main concepts have been determined; criteria for diagnostics for the level of training of students in mathematics have been chosen.

Secondly, the basic ideas of the information cybernetic approach have been developed and experimental work, which meant creation and introduction into the educational practice the methodology of training of future engineers in mathematics at university on the basis of the ideas of the information cybernetic approach, has been organized.

The third stage is parallel to the second, the author conducts pilot training and approbation of the proposed methodology taking into account the chosen resources.

## RESULTS

We turn now to the direct description of the structure of the methodology for training future engineers in mathematics on the basis of the information-cybernetic approach. The features of each stage of the developed methodology of training in mathematics will be characterized and revealed. The implementation of the stage "I get

to know myself" was carried out in the form of a series of webinars, chats, forums, as well as full-time interaction of teachers and students. The goal of the stage is the formation of students' positive motivation to study mathematics; determination of students' individual and personal characteristics, diagnostics of the initial level of mathematical training. At this stage, the following tasks were solved: to reveal the level of motivation to study mathematics and to acquire a future profession; to determine the "initial" level of mathematical training; to identify "barrier" mechanisms for studying mathematical disciplines; to diagnose the formation of skills of self-organization, self-control and reflection; to identify individual belonging to a type of cognitive modality. At this stage we held the webinars "I want to be an engineer – let them teach me!"; "Information crystals" (Effective methods of information processing); "Secrets of time management"; "Kaleidoscope of scientific discoveries"; "Not dull mathematics"; the chats: "The engineer of the third millennium is an engineer of the future, what is he/she like?"; "Mathematics (physics, chemistry) for the engineer: myth and reality"; the round table "Legacy of the past (about great inventions, discoveries and scientists)", the following techniques were used: cinquain, constellation Engineer, desire tree; five fingers, "fish-born", "thick" and "fine" questions.

The goal of the webinar: "I want to be an engineer – let them teach me!" is forming ideas about the profession "Engineer", acquaintance with its history, development prospects and specific features. During the webinar, students were offered various forms of work: individual - analysis of professiograms, work in the chat; group discussion on problematic issues. It should be noted that the question of the future engineer's activities and engineer's personal and professional qualities caused the greatest interest among the students. At this stage we used such techniques as "One day of life ..." and "Unfinished sentences". The technique "One day of life ..." suggested the students to describe the activities of the engineer using seven nouns (in accordance with the specifics of the training program).

It should be noted that this task caused considerable difficulties for students, they mentioned that they did not know in detail the specifics of future professional activity. The technique "Unfinished sentences" offered the students to complete the unfinished sentences: "I believe that being an engineer ...", "I want ...", "I know that ...", "If I could, I would change ...", "The engineer should possess ... ", etc. The fulfillment of this task caused positive emotions among students. However, the evaluation of the responses allowed us to conclude that the knowledge about the profession is fragmentary. As the result of the survey and during the discussion of problem situations, we came up with the problem of reasonability of considering the specifics of engineering activity, its components, as well as the professional and personal qualities of the modern engineer. A joint discussion of the issues with the students allowed us to formulate the following conclusion.

The modern engineer must possess mathematical and creative abilities, have high-level logical thinking, be stress-resistant, be able to organize his/her activities rationally, and to have self-improvement aim.

After analysing the professiogram, the students were asked to answer the question: "Which area of scientific knowledge is the most priority for the engineer?" This task caused discussion. About 40% of webinar participants indicated the leading importance of mathematical and natural science disciplines in the training the future engineer. But at the same time, students had difficulties in reasoning their opinions. The opposite opinion expressed by the students was that the modern level of technological development of the society, the availability of high-precision equipment and the possibility of computing through computers, do not require the modern engineer to have fundamental knowledge and skills in the field of mathematics and natural science.

The students could express their opinion on this problem during the chat "Engineer of the third millennium - the engineer of the future, what is he like?" To do the reflection as the final task, the students were asked to summarize the ideas presented and reflect their opinion by writing a cinquain on the topic "Engineer". It should be emphasized that this assignment had the most emotional students' responses. Here are examples of cinquain with varying degrees of emotional coloring.

| | |
|---|---|
| Cinquain *1:* | Cinquain *2:* |
| Engineer! | Engineer. |
| Clever, inquisitive;; | Complex, monotonous; |
| Analyses, invents, fixes; | Reads, goes to work; |
| I want to be an engineer! | An engineer has to work hard |
| A step in the future! | Full stop. |

In the first response we can observe a positive characteristic of the activity of the engineer, the personal interest of the author in acquiring the future profession. In the second response, on the contrary, the student is very detached: "The engineer has to work". The adjectives and verbs used do not reflect the formed view of the profession being acquired.

Thus, the analysis of the responses received during the webinar and chat allowed us to draw the following conclusion. Students have fragmentary ideas about the profession of "Engineer", they are not familiar with the specifics of the engineer's work (in accordance with the chosen training program). In addition, not all students are aware of the importance of mathematical and natural science disciplines for the future professional activity.

The abovementioned has served the basis for webinars "Kaleidoscope of scientific discoveries" and "Not dull mathematics". The first webinar was aimed at acquainting the students with discoveries and inventions of the engineering activity, as well as the field of natural science. In particular, during the lesson, modern technologies (nano-, bio-, information technologies); promising branches of development of electric power industry, industry, resource-saving production direction, etc. were considered. We note that the goal of the webinar was not only acquaintance and systematization of knowledge about promising directions of engineering activity, but also demonstration of the key functions of scientific knowledge in the development of the modern industrial complex of the country.

Active dialogue during the webinar, as well as comments left by participants in the chat ("What is it?", "I would like to know more about this", "And where can it be used?", "Will we study it?" etc.) allowed us to assert about a sufficiently high level of students' personal interest in the problems under consideration.

The main idea realized within the framework of the webinar "Not dull mathematics" was aimed at forming ideas about the value of mathematical disciplines for the future professional activity of the engineer. The presentation of the material was constructed taking into account the selected content. In the framework of this lesson, students were able not only to get acquainted with the history of the development of mathematics as the oldest science, but also to analyze the functions of the mathematical apparatus for solving applied problems.

The discussion "Mathematics around us" was particularly interesting for the students. The real scientific fields and industries, where certain mathematical objects are used, were pointed out during this discussion. For example, the use of matrices and determinants to describe rotations in classical mechanics; dielectric and magnetic permeability - in anisotropic media, etc.; the use of the theory of complex numbers in mathematical physics, electrical engineering, hydrodynamics, cartography, etc.

The students' personal interest in the stated problem was concluded by analyzing the students' comments like "I thought it was just a set of numbers!", "Very interesting", "I think now my attitude to mathematics will change ...", "It turns out that mathematics is everywhere", etc.

The obtained results proved the reasonability of finding means and methods aimed at improving training future engineers in mathematics. In addition, the implementation of the stage "I get to know myself" through the use of such forms of organization of educational and cognitive activities as the webinar, the chat, the forum created conditions for the development of the students' positive motivation to master the future profession, to understand the importance of mathematical training, to determine the skills of self-organization and reflexivity level. Comprehension of the research results after the first stage "I understand myself" was significant for us and was taken into account when organizing and conducting lessons at the next stage of the methodology. This stage is multicomponent and is represented by three main stages: "intellectual puzzle", "entertaining modeling", "creative

laboratory". For each student, taking into account his/her personal and individual characteristics, an individual educational path was formed. It should be noted that the stages of the selected methodology are correlated with the level of complexity of the educational material. At each of the presented stages the students were offered multi-level assignments.

The stage "Intellectual puzzle" is aimed at the formation of algorithms for actions related to computing operations in mathematical and natural science disciplines, the reproduction of basic chemical and physical laws and propositions. At the same time, theoretical material was presented both in full-time and remote interaction (through organized video lectures, webinars, problem forums and advisory chats). The practical part of the training material was presented by a set of tasks, which completing requires the reproduction of formulas, laws, propositions, actions carried out in accordance with the model ("task-algorithms"). In the process of solving tasks, the students actively worked with electronic reference books and glossaries.

The possibility of manifesting the students' subjective position was realized during the webinars. At this stage, the greatest interest among students was caused by online lessons like "How to distinguish lies from the truth? The solution of logical problems"," Rises and falls "," At natural science's".

It should be noted that the key feature of on-line lessons was the integrative character. In addition, these webinars contributed to the systematization of knowledge as their functions are also informative and motivational. This ensured a deeper understanding of the essence of the issues studied by the students and an awareness of the importance of mathematical training in the context of future professional activity. So, at the "intellectual puzzle" stage, it was advisable to acquaint the students with the cognitive, applied and integrative functions of mathematical knowledge.

All that has been mentioned above was implemented during the on-line session "How to distinguish lies from the truth? Solving logical problems". The choice of the topic of the session is conditioned by the results of the initial diagnostics, according to which more than 30% of the students experienced difficulties in reasoning their opinions, evidence, and the establishment of cause-effect relationships. This is a serious "barrier" not only in mastering the next step "Entertaining modeling", but also in the formation of a dedicated cluster of competencies in general. In the course of the webinar, students were able not only to get acquainted with the cognitive function of mathematical disciplines, but also to update knowledge on the application of techniques, operations and laws of mental activity when reasoning. During the lesson, students updated their knowledge: the propositions of formal logic, laws, forms of logical thinking, methods of argumentation, methods of establishing and analyzing cause-effect relationships. At this lesson, we first considered the specifics of the engineering thinking of a specialist in the 21st century. During the joint conversation when answering the problem questions, it was concluded that the future engineer should develop the ability to reason, combine, "build" conclusions, freely master the concepts of mathematical disciplines, establish logical connections.

The discussion and group decision of the presented problems was on-line and the brainstorming method was used.

The latter suggested obtaining a solution as a product of joint activity (creativity) and subsequent detailed analysis of its results. The value of this approach at this stage was determined by the fact that the technique used was aimed at generating new ideas on possible solutions to problems; analysis and evaluation of the proposed assumptions by students, the formation of their subjective position. We also used techniques such as "confused logical chains", "thick and fine questions", "cross-discussion".

"Confused logical chains" allows to trace the cause-effect relationship or chronological chain of events, focus on the variability of the development of certain situations. The value of this technique is the students' awareness of the significance of cause-effect relationships. In the course of the webinar, we made certain that very often the reason is replaced by the consequence in the analysis of the event, and vice versa. This leads to a false assessment of events and can significantly affect the final result of the solution to the problem.

"Cross-discussion" was used to organize the work of students in small groups. During the lesson, the students were offered a binary question, discussing it they had to express thoughtful arguments (counterarguments) and also demonstrate the ability to listen to their opponents.

"Thick and fine questions" was applied at the final stage of the session with the aim of summarizing the results and organizing feedback from students. They were asked to answer "fine" questions ("who?", "what?", "when?", "do you agree?", etc.) independently and "thick" questions ("give an explanation ...", "why do you think ...", "what's the difference ...", "guess what will happen if ...", etc.) were discussed together. Students noted that the use of this technique contributes not only to concentration of attention, development of thinking, more effective assimilation of the studied material, but also to the discovery the methodological potential of the disciplines that are studied. The applied function of mathematical and natural science knowledge was illustrated during the webinar "Rises and falls".

The lesson was focused on the formation of students' algorithmic culture. As the main means of training at this stage "research tasks" (optimization tasks) were considered. The latter tasks assume determining within a region of extremum a real-valued function. The implementation of the algorithm for the research of a function contributes to the formation not only of an algorithmic culture, but also to the formation of skills in analysis, interpretation of data, forecasting a possible result. In particular, at this stage, students were asked to solve tasks for solutions that are aimed at determining the extreme values of the target values (minimum friction coefficient, maximum slope, maximum concentration level, etc.). Some examples of such tasks are: "In a air-holder, a piece of ice of mass M floats in water, into which a lead pellet of mass m has frozen. What is the minimum amount of heat you need to spend to make the pellet begin to sink? Lead density is 11.3 g/sm$^3$, ice density is 0.9 g/sm$^3$, heat of melting of ice is λ. The water temperature in the vessel is 0°C."

The value of the lesson was due to the fact that the future engineer needs to be able to choose from several factors affecting the process or phenomenon that would contribute to its optimization. The students' attitude to the studied issue, as well as their emotional state, was diagnosed by means of the reflexive technique "Five Fingers".

The next step of the proposed methodology is "Interesting modeling" aimed at developing the skills of using a mathematical apparatus for modeling various processes of animate and inanimate nature. At this stage mainly research tasks were proposed. They were aimed at developing students' analytical abilities: analyzing information in order to identify the natural-science essence of problems; methods of correct expression and reasoned justification of the point of view; forecasting possible consequences; formation of ideas about mathematics as an "instrument" for describing the phenomena of the world and the processes associated with the future professional activity. At this stage, such on-line lessons as "Live differential equations", "Mathematical architecture", "Constellation of natural science", "Short circuit" were held.

The students were especially interested at the lesson "Live differential equations". The purpose of this lesson was to create the conditions for the formation of analytical and research abilities, the ability to model the processes of animate and inanimate nature and to interpret the data.

During the webinar "Live differential equations" problematic situational videos such as "ecological crisis", "unusual path", "temperature fluctuations", "radioactive decay", "effective deal", etc. were offered. In each video-situation, a real problem was described, the solution of which was proposed to find using the basics of mathematical and natural science knowledge. Moreover, the students independently tried to describe the existing problems of science and technology using mathematical language. To do this, they were offered "direct" and "reverse" tasks. At first ("direst" tasks), it was necessary to create and analyze the given model according to a certain condition. Secondly ("reverse" tasks), it was offered to reconstruct the problem essence using a given model. It is very valuable, in our opinion, that in the course of doing the task, most students tried to reflect the object of their future professional activity, its specificity when they formulated the task.

The next step "Creative laboratory" was aimed at developing imagination and system thinking; formation of skills for forecasting the development of technical systems, research and reflexive skills. Achieving this goal is

possible due to the implementation of ideas of the heuristic approach, the use of non-standard ways of thinking, etc.

At this stage, students were offered tasks with a somewhat "fuzzy" condition, from which it is not clear how to act, what to use when solving the task, but the required result is understandable. To solve these tasks, the students were highly-motivated, they had high level of self-control and self-esteem. They demonstrated confident knowledge of the mathematical apparatus and knowledge of natural science disciplines, put forward hypotheses when solving non-standard tasks, and they showed the ability to interpret data and predict possible consequences. Approbation of the methodology developed on the basis of the information cybernetic approach gives grounds to believe that its experimental implementation will contribute to the improvement of the mathematical training of engineers at university.

## DISCUSSIONS

The study of problems of informatization of education, the introduction of information and communication technologies, distance educational technologies and e-learning technologies into educational practice are reflected in the works of A. A. Andreev (2011), I. G. Zakharova (2010), E. C. Polat (2008) I. V. Robert (2011), A. V. Khutorskoy (2010), etc. The studies of Yu. P. Pokholkov (2012), and others are devoted to the problems of teaching future engineers.

The research of E. V. Maikov (2006), N. I. Naumkin (2006) and others are devoted to various aspects of improving the professional training of engineers.

The analysis of psychological, pedagogical and mathematical-methodical literature, the experience of teachers of mathematics shows that the formation of a competitive personality of the future engineer when teaching mathematics at university on the basis of the information-cybernetic approach is of great importance. In particular, the atmosphere of cooperation and dialogue is ensured; the educational and cognitive activity is activated through the providing professional direction of teaching; integration of forms, methods of interaction of subjects of the learning process occurs.

However, studies on the theory and methodology of teaching mathematics have not yet considered holistic methodological concepts that implement the information cybernetic approach in teaching mathematics to future engineers at university. Questions of mathematical and natural-science training of engineers are reflected in the works of L. R. Zagitova (2014), L. V. Medvedeva (2001) and other works devoted to the disclosure of the characteristics of mathematical and natural-science training of T. M. Bannikov (2012), N. N. Gazizov (2007), V. A. Eliseev (2007), etc.

The complex system of training engineers as well as its individual aspects has become the study focus of O. V. Zhuikova (2013), P. S. Lerner (2005), O. N. Martynova (2008), V. I. Mushtaev (2005), etc. The points revealing the didactic potential of new educational technologies (information and communication technologies, distance educational technologies and e-learning technologies) are reflected in the works of D. N. Monakhov (2013), A. V. Solovov (2006), and others. Ideas of individualization and differentiation of the learning process are discussed by M. A. Akhmetov (2009), T. B. Grebenyuk (2009), S. I. Osipova (2013), I. E. Unt (1990), etc. We find the following point of view very interesting. Foreign researchers suggest the principle of diversity of learning to mean "bring your own devices" in the implementation of the information cybernetic approach. Sharing their opinion, as well as the opinion of the researcher A. S. Urustemkhanova (2013), and others, we believe that the implementation of this approach provides prerequisites for creating a special environment in modern educational space that should not be limited by the computer only as the main means of education. At the same time, it is necessary to pay attention to the organization of electronic communication in the educational process. Sharing the position of N. A. Kocheturova (2009), we believe that electronic communication is an interaction between two or more people, carried out in an electronic environment through the computer or other technical means. As A. E. Zhichkina (1999) noted, electronic communication is characterized by a number of psychological, sociological, technical, linguistic and other features. In addition, we are of the same mind with A. I. Yakovlev (2001) that the introduction of a new

electronic tool and the development of a new technology based on the use of technical training means are two fundamentally different tasks.

This point of view is also shared by B. S. Gershunsky (1999), who believes that "pedagogical technologies should not be limited only to the use of new information technologies based on the computer and other technical means to improve the effectiveness of the pedagogical process." At the same time, G. K. Selevko (1998) notes the considerable didactic potential of technical training means: "the use of these tools does not only significantly transform the structure of the educational process, but also creates exciting opportunities for its intensification." Ideas of V. I. Soldatkin (2002) are also interesting, they emphasize that the choice of the technology should be determined by the following rule: 40% of the time should be full-time interaction, 40% - distance learning, 20% - self-education. A. N. Pechnikov (2014) singles out a number of requirements that should be taken into account when organizing training with the use of technical training means and the implementation of the cybernetic approach, namely: students must achieve a certain quality of training, the achievement at a given level must be rational and in accordance with students' individual characteristics; the material must overcome the contradiction between the increasing volume of information in a particular subject area and the limited time for its assimilation; compliance with the requirements of health-saving technologies that prevent design-ergonomic, psychological and physical loads.

## CONCLUSION

The problem we are studying – the training of engineers and technicians in mathematics at university– has been analyzed from the perspective of different levels of cognition:

- **Methodological**-in the context of integrating the ideas of information and cyber-oriented approaches;
- **Theoretical–**comprehension of the phenomenon of the information-cybernetic approach from the position of scientific foundations of pedagogy; conceptual ideas of cybernetics (identification of features of versatile management of the learning process); modern level of development of computer science (analysis of information and technological potential of the environment);
- **Methodical–**development and approbation of the methodology of training students in mathematics at university.

The conducted research allows to formulate the following conclusions. The revealed pedagogical potential of the information-cybernetic approach in teaching mathematics engineers at university are the following possibilities:

- ***motivation-adaptive:*** taking into account psychophysiological features and individual characteristics of students; creation of simulation situations; ensuring an atmosphere of cooperation and dialogue;
- ***subjective:*** granting the student the right to choose the learning path with its subsequent correcting; activation of educational and cognitive activity by providing professional direction of teaching, using e-learning technologies;
- ***integrative***: integration of the content of mathematical disciplines with elements of professional knowledge, based on the generality of the studied concepts, interdisciplinary relationships; integration of methods, forms and means of teaching;
- ***diagnosticable and regulative:*** the implementation of operational feedback; providing continuous pedagogical support for the students' classroom and out-of-class work.

The authors have justified and presented the methodology for teaching mathematical disciplines engineers at university. The specificity of the methodology is reflected in the following stages: "I get to know myself", "Intellectual puzzle", "Entertaining modeling", "Creative laboratory". The developed methodology is related to the specifics of the mathematical training of engineers and allows to maximize the potential of the information cybernetic approach.

## RECOMMENDATIONS

The materials of the article can be useful in practical terms for university teachers of mathematics who are striving to greatly improve the level of training of future engineers in mathematics.

The research carried out has a prognostic value, as it creates real prerequisites for further scientific research when studying the specificity of the information cybernetic approach in educational practice, taking into account the development of information and technological characteristics of modern society, the flexibility and changing objectives of Federal state educational standards, the sophistication of knowledge-intensive and technological spheres of production.

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