Innovative approaches in the training of engineering personnel

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Abstract. The article is devoted to the problems of using innovative technologies in the process of training future specialists in the field of applied physics and engineering. The necessity of development and implementation of innovative technologies in higher education is substantiated. The effectiveness of the proposed technologies is evaluated in terms of the formation of professional competencies of bachelors. The article considers innovative approaches and the corresponding educational technologies. The experience of the development and integration of innovative technologies in the educational process of a technical university is described on the example of teaching mathematical subjects for students. The article describes the experience of the effective use of electronic educational environment of the university to create original elements of electronic educational resources, considers the possibility of introducing students to VR \ AR technologies in the framework of project activities. The article discusses the results of a training experiment in which students of technical training areas participated.

1. Introduction

In the national educational doctrine of the Russian Federation for the period, until 2025, one of the priority issue of higher education is the training of highly qualified specialists, which is carried out in the conditions of total informatization of society and the rapid development of high technology. Its goal is the formation of a competitive and efficiently functioning sector of research and development and ensuring its leading role in the processes of technological modernization of the Russian economy. The process of implementation of this strategy involves the usage of the scientific potential of universities.

Article 20 of the Law "On Education in the Russian Federation" states that a modern educational institution should be the center for the formation of innovative behavior of the subjects of the educational process. A number of researchers, including A.Sh. Bagautdinova [1], N.Ya. Saigushev, O.A. Vedeneeva, Yu.B. Melekhova, L.S. Ryazanova, M.V. Konovalov [2, 3] note a significant difference between the orientation of vocational training and the content of the future activities of a university graduate. The implementation of an innovative approach to the organization of the educational process according to the requirements of our time is one of the current areas of activity of universities. These requirements set new issues connected with the development of effective educational technologies and techniques that provide high professional qualifications of university graduates.
Innovative technologies should be aimed at solving such urgent problems of modern higher education as the improvement of the efficiency of learning; the increasing cognitive activity of students; the activation of the independent cognitive activity; the formation of value orientations of students' personality; the development of creative abilities; the formation of practical research skills to make professional decisions.

2. Materials and methods
In the process of research, the authors relied on the provisions of the activity, competence and design approaches. During the work key concepts and their relationship are analyzed. During the research the authors conducted an analysis of normative documentation, that defines the main goals and principles of Russian education development, as well as an analysis of internal documentation in the university, that is related to the learning process within the given problems. The practical work experience in the field of teaching mathematical disciplines in a technical university was analized. In the process of conducting the experiment and analyzing its results, such methods and techniques as direct and indirect observation, interviews, questioning of students and teachers, student testing, methods of mathematical processing of statistical results of the experiment, qualitative and quantitative analysis of the results of experimental work were used.

3. Results and discussion
The term "innovation" comes from the Greek and means renewal, change.

An analysis of the scientific literature indicates that in the most general sense, an innovation is the end result of innovative activity, embodied in the form of a new or improved product, a new or improved technological process [3].

In the modern scientific understanding, innovation in education is aimed at creating a new type of educational practice, developing on the basis of relevant science-based ideas, concepts and approaches [1]. Pedagogical innovation is an innovation in pedagogical activity, a change in the content and technology of teaching and breeding, aimed at increasing their effectiveness [2]. According to the degree of the novelty, innovations are usually divided into levels. The highest-level innovations include an educational product that has no analogues. At the following levels, we are dealing either with the improvement of a well-known educational product, or with its usage in new conditions, for the implementation of new goals.

In real educational practice, innovation is often interpreted as the antonym of the traditional approach, focused on reproductive learning, the assimilation of ready-made patterns, concepts, actions, as going beyond the typical, frequently encountered techniques, methods and teaching methods [1].

Innovations in higher education can be divided into two levels according to the global scope of the tasks. The first is a common level, which generally characterizes the university, evaluating its innovativeness. The university innovation is a diverse concept, which includes the creation of an educational innovative environment, the creation of conditions and prerequisites for active scientific research activities of teachers and students and much more [1]. The second level is determined by the innovation of methods and means of teaching in a particular discipline within the training for a specific educational program.

The issue of innovative educational technologies, which are the result and reflection of modern trends in the development of society, is discussed by many researchers.

Benzi Slakmon, evaluating the educational policy in Israel, notices that the main feature of modern education is the introduction of a national educational information space [4]. We believe that this trend is also defining for Russian education.

New, actively and universally implemented in the practice of education, phenomena include e-learning. People believe that it provides great opportunities for teachers, students and administrators of education. However, in reality, e-learning quite often comes down to the usage of insignificant technologies (for example, presentations or student testing). Practice shows that a complete transition to training with the help of video films and testing does not satisfy students.
Wong, Olugbenga T. Oladinrin, Christabel M. F. Ho, Eric Guilbert & Roy Kam [5] talk about this problem through the example of teaching undergraduate construction students. K. Naidoo, R. Naidoo & K. Ramdass [6] confirm this idea. The idea is confirmed by the works of P.Y. Romanov, L.V. Smirnova, O.A. Torshina, S.V. Akmanova, L.V. Kurzaeva, N.A. Kopylova [7; 8]. They, like the authors of this article, come to the conclusion that blended learning is the most effective.

With the help of the information environment of the university, the Flipped Classroom teaching strategy, which has recently been of particular interest to methodologists and researchers, can be successfully implemented.

The results of applying this strategy to teaching mathematics to students are discussed in the articles of V. Jungić, H.Kaur, J. Mulholland, C. Xin [9], L. Abeysekera, P. Dawson [10], X. Cheng, K. Ka Ho Lee, E.Y. Chang, X. Yang [11], Z. de Araujo, S. Otten, S. Birisci [12]. The main reason for this interest is the lack of effectiveness of teaching methods using the traditional lecture approach. The authors H. Turra, V. Carrasco, C. González, V. Sandoval & S. Yáñez experimentally prove the benefits of using the Flipped Classroom “inverted classroom” approach [13]. According to these researchers, "the Flipped Classroom leads to higher satisfaction levels due to the characteristics active learning, collaboration between students, closeness with the teacher and ease of learning through educational videos" [13, p.136].

We use the elements of this strategy in our work, however, we believe that a full transition to training using the Flipped Classroom method is not justified.

One element of the Flipped Classroom strategy is testing. Many researchers and practicing teachers in higher engineering education come to the conclusion that testing can and should be more than just a test. It must carry a learning load. The Flipped Classroom concept supposes a training testing as part of mixed learning. The organization of students' independent work in the conditions of the Flipped Classroom has a number of disadvantages connected with the organization of self-control and students' assessment of the results of their activities. We believe that these disadvantages can be partially or completely eliminated with the help of educational tests.

Liam Comerford, Adam Mannis, Marco DeAngelis, Ioannis A. Kougioumtzoglou & Michael Beer discuss this issue in their researches [14]. They go through the development of the software that allows them to put into practice the formative methods for assessing the results of students' educational activities in the independent educational work.

Over the recent years, the exams, conducted in the form of the Internet testing, have been actively introduced into the practice of higher education. This form of knowledge control has several advantages over the traditional form of examinations:

- objectivity of the assessment (minimization of subjective factors);
- effectiveness (the ability to simultaneously test a large number of students, while checking the results is relatively easy and fast);
- the clear interpretation of test results;
- the ability to use tasks of various difficulty levels in tests;
- the ability to compare test results in different groups.

Within the preparation for them, the Internet simulators are offered. Having analyzed the systems of the Internet simulators and the Internet exams, that are available for us, we came to the following conclusions:

- not all the disciplines, included in the curriculum for the preparation of bachelors or masters in the mentioned areas of training, are present in the well-known and available Internet testing systems;
- a number of disciplines included in the database are represented by a limited number of tasks, which does not allow us to work through separate topics in detail;
- the systems of the Internet simulators due to technical and financial problems are not always available to teachers and students.

Therefore, one of the priority activities of universities is the organization of its own massive base of testing materials in all disciplines, the creation of a simulators system.
One of the goals of the GEF in a technical University is the development of students' social and personal qualities, as well as the formation of general cultural, general professional and professional competencies in accord with the requirements of the state standard. These qualities provide social mobility and stability in the labour market of future graduates. Another goal is the formation of bachelors' readiness for active professional and project activities, personal qualities, cultural and ethical values.

The goal of mastering the discipline "Mathematics" within the specified educational program is the formation of a general cultural competence, which includes:

- the education of sufficiently high mathematical culture;
- the inculcation the skills of modern types of mathematical thinking;
- the inculcation the skills of using mathematical methods and the basis of mathematical modeling in practice.

The education of students of mathematical culture involves:

- a clear understanding of the need for a mathematical component in the general preparation of the bachelor,
- the development of ideas about the role and place of mathematics in modern civilization and in world culture,
- the ability to think logically, to operate with abstract objects and to be correct in using mathematical concepts and symbols to express quantitative and qualitative relations.

The mathematical education of bachelors should be broad, general, rather fundamental. Particular attention should be paid to the applied orientation and orientation towards teaching students to use mathematical methods in solving applied problems. The general course of mathematics is the base of the mathematical education of a bachelor.

Currently, the idea that it is enough for a modern engineer to be able to use existing mathematical packages is actively promoted. In the framework of higher education, this often leads to the fact that the study of mathematics in the first years is replaced by learning to work in mathematical packages. This does not allow us to talk about the fundamental nature of student training.

Professional mathematical packages simplify routine computational operations, but introduction with them should be carried out after mastering the basic mathematical concepts, methods and techniques, that form the basis of applications. At the initial stage of teaching mathematics, we permit the usage of calculator programs, that are freely available on the Internet. To a greater extent, they contribute to the organization of self-control among students and the implementation of calculation tasks and project works. In the process of teaching we demonstrate to students how mathematical methods work in the professional field.

It is advisable to start the introduction of innovative technologies in education from the first days of study at a university in order to effectively form the general professional competencies of a future graduate. Mastering the discipline "Mathematics" and the related disciplines of the natural science block is considered as creating the foundation for the successful development of the disciplines of the professional block. The main worldview task in the study of mathematics is the comprehension of reality through mathematical models. Many authors speak about the need to create such a basis and teaching methods in their research. D. Leiss, J. Plath, K. Schwipert are among them [15], as well as P.Y. Romanov, L.V. Smirnova, O.A. Torshina, S.V. Akmanova, L.V. Kurzaeva, N.A. Kopylova [7,8], L.I.Savva, A.E. Kameneva [16].

Trends in the radical reduction of hours, devoted to classroom communication between the teacher and students, do not allow the educational program to be implemented within the standard teaching methods and tools. They require the creation of innovative educational technologies in the context of a particular discipline.

The construction of a new educational technology has become possible through the usage of the information environment of the MOODLE university. Recently we have been actively exploring the opportunities, means and tools of the educational portal of the university. Electronic educational resources have been developed and implemented on all key topics in order to fill the courses. Lectures (in text
format, multimedia, video), practices, laboratory works, multivariate standard calculations and developments for individual homework are among them. A bank of questions and tasks for online testing is being developed on all studied topics. Modern technologies allow us to create effective training monitoring tests. The development and improvement of testing technologies for teaching mathematics using various libraries, for example, Acrotex, is one of the main methodological problems that the authors are solving [17]. Within these technologies, an individual approach to students is effectively implemented, which contributes the development of self-learning, self-organization and reflection skills. The results are presented in works [18, 19, 20].

Tests, as means of control, allow us to get objective assessments of the knowledge and skills level, identify gaps in training. In combination with online training programs, MOODLE and materials, which are created by teachers and adapted to a specific university and a particular direction of training, tests allow us to switch to adaptive learning and knowledge control.

Informatization of education stimulates us to search for and introduce new forms of lecture, practical and laboratory studies. During active work with the educational portal of the university, the practice of remote lectures and practical exercises is implemented.

Teaching mathematics to students should be carried out as part of the project approach [16]. The knowledge, acquired by a student, is often theoretical. Working on the study project corrects this disadvantage, allowing the student to show educational and professional initiative. At the initial stages such work of training forms the presence of certain subject knowledge, skills, ways of thinking and an understanding of the measure of responsibility for actions and their results. We see it as appropriate to introduce students to VR/AR technologies within the framework of the project approach. Virtual and augmented reality are new tools for education, but they can qualitatively complement learning, make it more accessible and exciting [21].

4. Conclusions
Summing up the done work, we can note that the considered innovative approaches and the corresponding educational technologies contribute to solving a number of urgent problems of modern higher education. Among them: the increase of the students' cognitive activity; the effective assimilation of knowledge; the formation of practical research skills to make professional decisions; the transition from the accumulation of knowledge to the creation of mechanisms for independent search and research skills; the development of creative abilities.

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