Problem-based learning for technical students on the base TRIZ (theory of inventive problem solving)

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Abstract. The basis of modern educational technology in teaching is problem-based learning through the use of educational technologies Powerful Thinking - Theory of Inventive Problem Solving (TRIZ), including a systematic approach to the complex organization of independent work of search and research character. Developed by systemic administration of the physical features workshops on the basis TRIZ in the cycle of the natural sciences with the implementation of all aspects of the educational activities - substantive, procedural and motivational. A new model of the physical design of the workshop and its form of organization, which is based on problem-based learning with the use of TRIZ Interactive form of organization of the workshop allows you to get high-quality substantive and personality of the students who have a significant role in the formation of professional competencies and affect the quality of produce practice-oriented specialists.

1 Introduction

Innovative training programs provided for in the concept of modernization of Russian education for the period up to 2020 [1], put the task of preparing and producing practice-oriented specialists. They should have considerable creative potential and lead a multifaceted scientific-innovative activity across a wide range of specialties and high technologies. Solving these problems, taking into account the specifics of the open education can be obtained on the basis of the research, problem-oriented and contextual approach to teaching. It should be possible to combine fundamental and professionally oriented education. Physics, in conjunction with other basic sciences, is the basis of high-tech stages of development of modern society. So mastery of the relevant physics methodology should be seen as an essential part of high-grade engineering education. The development of a creative personality, equip the future graduate of a technical college the modern methodology of scientific research and innovative activity able to independently and competently to solve actual problems of science and technology, is one of the fundamental objectives of higher education.

Despite the special importance of the issues in the most technical college's targeted research in the development of the methodology of teaching natural sciences were not carried out. Analysis of the results of scientific and methodological activity also shows that detail did not consider the development of new concepts, content, organizational and procedural forms and methods of teaching natural sciences. At the stage of

research and initial development is the development of creative, educational and independent activity of students of a technical college in view of specificity of open education and relevant program of modernization of Russian education [2, 3].

The analysis of innovative programs of Russian higher technical education (2001-2015 yy.), scientific research on the problems of studying the natural sciences, it possible to identify in the context of these problems a number of contradictions in the existing system of education in technical colleges:

- between the demand of modern society for specialists capable of using high-tech methods of physical research in their fields of activity and the lack of a real possibility of the formation of high-quality in open education in view of the existing methodical system of teaching natural sciences in technical colleges;
- between the need to strengthen the methodological orientation of the educational process and formation on this basis of professional competence in the field of scientific and research activities, as well as updating the communication content of the natural science disciplines cycle with high technologies, on the one hand, and the predominance of methodology transfer subject knowledge in training, on the other hand ;
- between the wide application in the formation of modern information technologies, on the one hand, and the lack of sound models of their effective application in all kinds of activities in the cycle of natural sciences;
- lack of an effective model for assessing the quality of e-learning, which hinders the formation of professional competencies, providing research and promotional

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activities of the expert, the ability to solve actual engineering tasks independently and professionally.

Discussed problems can be solved on the basis of purposeful changes in the content and methodology of the educational process in a series of scientific disciplines. These changes are primarily related to the actualization of creative learning activities in all kinds of activities with the use of information technology as a means of integration and synthesis of methodological and didactic principles and approaches in teaching methods. The basis of this technological approach to learning is problem-based learning through the use of educational technologies Powerful Thinking - Theory of Inventive Problem Solving (TRIZ), including a systematic approach in all types of learning activities and integrated organization of independent work of search and research character in terms of continuing professional education [4, 5].

2 Problem-based learning with use TRIZ (theory of inventive problem solving)

Construction of physical workshop is based on problem-based learning with the use of educational technologies Powerful Thinking – Theory of Inventive Problem Solving [6]. Interactive form of organization of the workshop allows you to get high-quality substantive and personality of the students, as well as forming common cultural and professional competence. The interaction of students with each other (work in small groups) and teacher generated communicative competence, which is necessary in the future in addressing developmental research tasks. Therefore there is a need to develop the most advanced techniques, approaches and technologies in teaching.

For visual and availability of training material, you can use a virtual computer model (Fig. 1).

Fig. 1. Observation of the photoelectric effect in a virtual computer model [7]

Introduced virtual physical laboratory practical research shows dependence of the saturation of the photocurrent on the retarding voltage. For a given emission wavelength ($\lambda = 400$ nm) registered number of photoelectrons reaching the anode for a certain period of time ($t = 10$ s). Further, the delay is determined by the voltage for different wavelengths, wavelength range is from 400 nm to 600 nm at intervals of 50 nm. Calculate

the frequency of radiation for these wavelengths and plotted: the current-voltage characteristic for a wavelength of 400 nm and a retarding voltage dependence on the radiation frequency. This laboratory complex can be used in design activity of students in physics, in the performance of virtual labs. Such virtual models and experiments do not replace work done in the laboratory, but only complement them or used in remote access conditions, for example in carrying out independent work in physics, using the electronic portal of the educational institution. These models contribute to the development of creative thinking of students, formation of the research competence [3].

Problem – based learning on the basis TRIZ during such a physical workshop is that:

- students independently formulated the hypothesis that when interpreting the results of physical experiments either confirmed or disproved;
- only the teacher formulated the problematic situation and fined a problematic situation permits offered students;
- interpretation of the results of physical experiment is:
 - finding of cause-effect relationships;
 - the analysis of the results, which include: assess the accuracy of the result of physical experimental value and ways to improve the accuracy of measurements;
 - from the analysis of charts and analytical relations;
 - from the output of the hypothesis and explain the differences between theory and experiment.

This model is most accurately reproduces the physical phenomenon. The effectiveness of the learning process will be on the list of computer models and its functionality. This refers to the possibility of observing the causal relationships between physical quantities, as well as the impact of changes in the physical characteristics of the system state on the result and the character of the physical process. Performing the above criteria depend on the methodological approach, developed computer models and software product that meets the primary objectives of fundamental education.

In the course of this pedagogical experiment, we concluded that the most effective performance of the educational process is achieved through informative independence of students. This is the basis of a search of educational and research activities with the use of modern information technology, focused on mastering the methods of solving problematic situations, according to the latest problems of science and practice [3].

The practice of problem-based learning, based on TRIZ shows that the effectiveness of this pedagogical approach to teaching is provided by system-activity approach to the use of information and communication technologies [6]. On this basis it is possible to create actual models of conditions and situations that encourage students for responsible self-training, scientific research, as well as the conditions of a qualitatively new form of creative cognitive activity. It should be noted that the problem of the expansion of the field of study of the

problem of natural sciences in technical colleges, due to the use of modern information technology, provides an approximation of its contents to the current level of scientific knowledge and technological level of urgent problems requiring resolution. The task of providing high-quality and effective use in teaching methodology of physics as a science in its entirety requires training focused not only on the development of the system of subject knowledge, but also education system aimed at the formation of professional competence of students, to develop creative, extraordinary thinking. In this case, on the basis of physical workshops TRIZ act as an innovative technology in a series of scientific disciplines, transforming the nature of education in relation to the target audience, ensure the creation of high-quality conditions and methods of interaction of the teacher and the student, possible differentiation, individualization, organizations active participation of students in the work, as well as the generation of new forms of independent work.

Implementation of physical features workshops on the basis of TRIZ in the cycle of natural sciences requires the development of scientific and methodological support of training and appropriate methods and technologies of training, based on a systematic approach in all types of training activities. Federal State Educational Standard requires the use of a system-activity approach in the learning process. Efficiency of physical training on the basis of workshops TRIZ implemented in the development of the theoretical foundations of the creation of didactic and methodological tools that meet the objectives, concepts and methodology for updating of modern physical education in technical colleges, and the creation of practical tools for teachers, complex hardware and software and methodical means of ensuring physical workshops based TRIZ.

Analysis of results of workshops based on physical TRIZ in the cycle of scientific disciplines allows us to formulate the basic conditions for achieving quality education using information and communication technologies [8]:

- systematic use of physical features workshops based on TRIZ in a cycle of natural sciences with the implementation at all stages of the educational activities – meaningful, motivational and procedural;
- the use of didactic and methodological approaches in the important process of physical workshops based TRIZ in all forms and components of independent search of cognitive activity of students, consistent with the principles availability, consistency, optimal, consistent with the logic and methodology of physics;
- develop and implement appropriate objectives of physical education on the basis TRIZ approaches in methodology, implementing the methodology of renovation of physical education, and related information and communication tools that are used in the organization of independent work of students of a technical college;
- design and development of theoretically based interactive forms of learning, using visualization tools of physical models of theoretical and practical knowledge,

as well as methods and means of Computational Physics [9];

- development and application of modern methodological approaches and information tools to provide training, design and scientific-search activities of students, and to ensure that "quality of education" in lectures, practical classes and laboratory work using physical workshops based TRIZ [6].

Evaluation of "quality education" through the use of problem-based learning using physical-based workshops TRIZ carried out with the release of the three main vectors - the quality of the content of education; the quality of educational outcomes and the quality of educational technology.

It should be emphasized that the system of training using information and communication technologies, along with general approaches to quality assessment, priority is the design methodology of the educational model as a demonstration and training by means of information and communication technology training and evaluation of the effectiveness of its application. An important element of education quality assessment systems, are the criteria for assessing the quality of the course using information and communication technologies.

System evaluation of the quality of education in the context of the teaching of physics was held in areas of training - Physics and Computer Science, Energy and Techno sphere safety Construction. Used survey technology, with profile takes into account the fact that the statistical processing of the results of the survey carried out automatically with the integrated statistical package. This allows obtaining analytical results of the evaluation of teaching and the work of the teacher, the technological characteristics of the course, assessment administration.

3 Main results

The main results of the research on theoretical and practical aspects of the use of problem-based learning using physical-based workshops GT of PT – T of IPS in the cycle of natural-science disciplines are as follows:

1. The educational process in physics using physical workshops that are based on problem-based learning and TRIZ meets the objectives of fundamental education. This ensures its effectiveness in preparation for future practice-oriented graduates. This optimal use of the methodology of physics as a science in combination with the system-activity approach contributes to the formation of students' professional competences significant. Interactive form of training develops the nature of the information cognition, cooperation and healthy competition; increase the motivation to learn, which in turn, allows you to combine training, control and self-control in a single creative process.

2. Developed the structure and content of modern educational and methodical complex of disciplines, as well as the control of students' knowledge practices, using new methodological approaches with the use of information and communication tools that meet the

system problem-oriented teaching physics and other natural sciences in a technical college.

3. It is shown that the educational process is based on problem-based learning techniques using physical workshops based on TRIZ aims, primarily to provide individual and group of independent activity of students to address the educational and research tasks on the basis of an adequate program goals, methodical and laboratory complex. This active use of technology TRIZ in the education system in an open continuing education provides additional opportunities for the full development of the principles and methods of science-intensive technologies.

4. Technology problem-based learning using physical-based workshops TRIZ, combining as one full-scale (computerized), a virtual experiment and computer simulation, It can serve as a basis for the creation of training a new generation of laboratory-oriented educational and research activities of students of a technical college at different stages of the educational process.

4 Conclusion

The practical significance of the work lies in the fact that it presents the theoretical basis for the creation and application of physical workshops, implementing technology problem-based learning based TRIZ technical and pedagogical universities, and recommendations for their implementation.

The results of these studies were tested at the Department of «Pure sciences» Private educational institution of higher education Moscow Technological

Institute and the department «Methods of teaching physics » Moscow State Regional University.

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