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INFORMATIONAL AND EDUCATIONAL ENVIRONMENT FOR TEACHING MATHEMATICS OF THE FUTURE ENGINEERS OF ART MATERIALS PROCESSING DEPARTMENT

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ABSTRACT

The description of Informational and Educational Environment that helps to facilitate the process of teaching mathematics of future engineers of Art Materials Processing Department at technical universities is presented in this article. The development of Informational and Educational Environment on mathematics will help to organize an intensive students activity in studying of mathematics as well as intensive activity of teachers whose work is to provide means and support for such types of educative processes.

Training results of Informational and Educational Environment application are not limited to acquiring certain amount of mathematical knowledge and skills but also imply the development of universal learning approaches and obtainment of personal experience.

Informational and Educational Environment's core element is informational and educational object medium in the field of mathematics. The content of the course was selected on the basis of utilizing comparative thesaurus approach, the main idea of which is to analyze the most popular mathematical and subject oriented textbooks to search out the most used mathematical and conceptual constructs. The process of teaching mathematics to future engineers of Art Materials Processing Department is based upon class exercises in higher education establishment (lectures, seminars and laboratory-based work), individual and group consulting tutoring, integrated lessons and out-of-class individual work.

The main teaching methods include engineering research method, systemic dynamics method and mathematical abstractions dynamic visualization method. Traditional means of education are combined with electronic multimedia sources, mental maps, simulators and interactive tests.

Results evaluation section includes electronic testing according to structure of mental maps in order to determine level of mathematical knowledge. Conducted pedagogical experiment showed that "Mathematical basis of painting and architecture" course training raises the level of mathematical knowledge of bachelors of Art Materials Processing Departments at technical higher educational establishments.

Keywords: Mathematical training, art materials processing department, technical higher educational establishment.

INTRODUCTION

Currently, the basis of fundamental education, which is provided at higher educational establishments, is formed by the level of mathematical knowledge acquired with the help of computer applications. It is impossible to cope with professional job tasks, which demand skills in application of computation experiment method, simulation modeling and data processing, without intensive usage of computer technologies and mathematical constructs.

The importance of high quality mathematical teaching from the school stage is also defined by the fact that learning process activates processes of cognitive abilities and some traits of students' personal character development.

Taking into account how important the level of knowledge in mathematics is in all aspects of science and technical equipment, it is fair to say that level of professional competency depend on the quality level of mathematical knowledge. This demands higher standards of mathematical education which means higher level of mathematical knowledge of students. However, the results of surveys conducted recently showed that level of mathematical knowledge deceases every year.

This problem is particularly acute for students of Art Materials Processing Departments of technical higher educational establishments.It have identified the following reasons for the low level of mathematical knowledge:

- **low level of interrelation of mathematics with vocational subjects and, as a consequence, lack of interest in mathematics;**
- **non-existent consideration for specific traits of perception of mathematical material by students of Art Materials Processing Departments;**
- **inadequate visualization of learning and teaching materials in mathematics.**

Development of Informational and Educational Environment for teaching of mathematics is seen by us as solution to this problems.

Transformation of the world into a single informational space, constant increase in volumes and update rates of information presented in a variety of forms afford ground for considering teaching process in general and teaching mathematics in particular, as a process, which is based on process of searching for, interpreting and processing information, process of information exchange with the help of ICT and process of creating new information (Pak, 2011). Development of Informational and Educational Environment (IEE) is now regarded as one of the necessary conditions to achieve a new quality of education.
The development of IEE for the purpose of teaching mathematics will help to organize intensive students activity in the field of acquiring of mathematical knowledge, as well as intensive activity of teachers, whose work is to provide means and support for such types of educative processes.

Training results of IEE application are not limited to acquiring certain amount of mathematical knowledge and skills, but also implies development of universal learning approaches and obtainment of personal experience.

The term "IEE" is relatively new and can be defined differently in various types of academic literature. The main concept of this term has been studied in the works of many scientists.
To summarize these definitions, we can say that the Information Environment is a set of:

- **information resources, which contain a variety of information provided on specific recording media;**
- **organizational structures that ensure its functioning and development;**
- **means of information exchange between teachers and students that provide both of them with access to information resources by means of software and hardware, as well as by means of organizational regulations.**

In the current study we understand the term *Information and Education Environment* as a set (system) of interconnected and interacting with each other information environments of different areas of knowledge that are sensitive to changes of information in outer environment and provide training, education and development of personal qualities of students.

The most common feature of any system is that its elements (i.e. the minimum structure-forming units) have a divisibility limit within its borders and functional and structural uniqueness as well as functional integration.

The second feature of the system lies in the fact that each element performs its function only in case of interaction with other elements of the system. Aforementioned features of the system are consistent in general with the essence of the concept put forward by (Kuzmina, 1980).

The key elements of the IEE for mathematical training as the system include:

- **integrity of the components that contribute to achieving the goal;**
- **dependencies and interdependencies between the components;**
- **presence of the driving concept, or leading idea, needed for combining the components;**
- **introduction of components common qualities.**

One of the important properties of IEE in terms of mathematical training is its openness, which manifests itself through the internal dynamics of its elements and communication between them. Basic functions of IEE in terms of organization process of mathematical training in accordance with the structural logical model of mathematical preparation for future teachers of natural science are the following:

- **ensuring open access to information, including access through network, and information exchange between the participants of educational process;**
- **developing demand for information (scientific, professional, educational and training materials) and information culture of students;**
- **coordination of students informational activity;**
- **brain building and development of students cognitive abilities;**
- **implementation of continuity process of mathematical training methods within the "school-college of education" system;**
- **implementation of professional orientation method in mathematical training process;**
- **implementation of interdisciplinary relations of mathematics with vocational subjects.**

Thus, functional components of IEE are environments, either of which, on the one hand, is an independent structure with its specific structural and informative content and implementation of its specific functions, and on the other hand, there is a inherent interrelation with other media. This interrelation provides for a new feature of environment unity, as well as for new environment in the form of a structural component of the whole educational environment.

STRUCTURE OF IEE FOR MATHEMATICAL TRAINING

All aforementioned factors has determined the choice for development following mediums within IEE for mathematics training of future engineers of Art Materials Processing Departments at technical higher educational establishments: Informational and Scientific Medium (ISM), Informational and Professional Medium (IPM), Informational and Didactic Medium (IDM), Informational and Educational Subject Medium (IESM) (Figure 1).

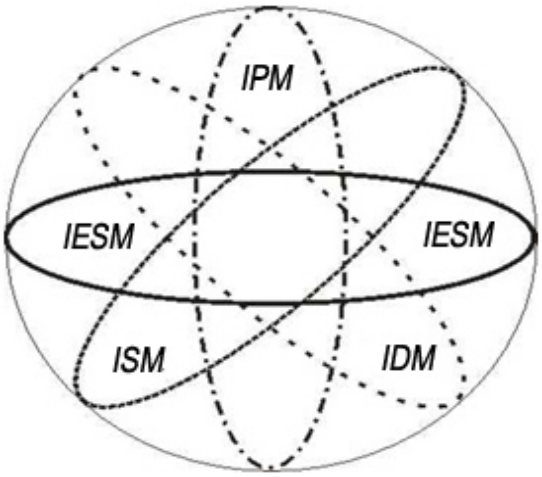

Figure 1.

Structure Of IEE for Mathematical Training Process

(Source: Tatyana P. Pushkaryeva, monograph. (2013). Scientific and methodical bases of training in mathematics of the natural sciences future teachers from the information approach positions, Krasnoyarsk, Russia)

ISM **is a complex of search and expert systems, as well as electronic versions of most significant scientific documentary sources and links to them: bibliographic descriptions of scientific papers on the problems of the art material processing, a list of the main sources of information on scientific and methodological problems in this area (author's abstracts, monographs, magazines, textbooks and teaching aids). Information and Scientific Medium development, as a component of a single IEE for bachelor's mathematical training, helps to eliminate education process' lagging behind current level of scientific knowledge and to ensure that one of the important didactic principles, the principle of scientific approach to teaching of mathematics, is carried out.**
IPM **is a repository that stores state educational documents for higher educational establishments, text and links to technical and fiction literature and academic materials.**

IDM **includes classical and didactic information principles of mathematical training for students of Art Materials Processing Departments at technical higher educational establishments.**

IESM **is a major component of IEE, which provides for sufficient level mathematical competence of future engineers.**

Currently, the fact of "development of informational and educational environment by each university is not an innovation, but one of the State requirements imposed on Higher Educational Establishments" (Shapiro, 1990).

And indeed, rapid development of computer technology, high rate of knowledge update process (including basic types of the knowledge), process of turning information into a commodity and into an important resource of social development and management tool have set up a task for higher education institutions to prepare specialists with new set of qualities, which are:

- **ability to adapt to rapidly changing conditions of modern society, to acquire on an individual basis all the knowledge and skills necessary for successful carrying out job tasks, to apply them in practice for coping with a wide variety of problems;**
- **ability to think critically and independently, ability to see problems emerging in the real world and to seek rational ways to solve them, using modern technology;**
- **ability to use information intelligently, to be able to retrieve and process information, as well as to use information resources, including the global ones, effectively in order to cope with job tasks.**

With the development of open education the problems of its development and maintenance in the present state of its methodological and technological basics became the most important one. The need to equip individuals with the desired set of educational competencies, capable of continuously replenish their knowledge, plan their learning process (choose methods, means and forms of training) using access to training resources at any time and any place, requires the development of conditions for balanced, uniform operation of all structural components of the educational process. In this regard, IESM plays a crucial role within IEE.

DESCRIPTION OF IESM FOR MATHEMATICAL TRAINING

The Concept of IESM

The term *Information and Education* Medium (IEM) denotes the totality of various subsystems, which provide informational, technical and academic conditions for organization of educational process, as well means for organizing participants of educational process. In the context of growing informational support of society and education process the necessity to create a single concept of IEM development have emerged. Such IEM should be fully capable to take into account the new possibilities of development, distribution and application of multi component distributed and integrated databases and knowledge-oriented education, as well as national requirements for the education system, which should be consistent with global trends.

The process of IEM development was the subject of a number of studies (Bashmakov and others, 1997). These authors propose various approaches to understanding the nature and structure of environment. However, in all of the studies learning environment components are divided into two categories as subjects and objects. The subjects of the educational process are students and teachers. "Objects are training resources and training tools of learning activities, methods, material resources, pedagogical process management area, ways of communication (organizational and administrative, promotional and motivational, ways of retaliatory behavior, technical and emotional ways)", (Solso, 2006).

The term *Informational and Educational Medium of higher educational establishment* refers to a part of the national information and educational environment, which includes:

- **information collections,**
- **telecommunication facilities,**
- **scientific and methodological support for disciplines,**
- **vocational subjects areas and**
- **professions, databases and knowledge bases, remote access to a variety of information resources, training systems and networks, digital libraries, informational education systems description and implementation technologies.**

Higher educational establishment *Information systems* are means of information technologies that are used in the training process and are able to determine the entire education sector and its individual components, such as objectives, content, methods, forms of training, education and development of students in educational establishments of any level and profile.

Informational and Educational Subject Medium for mathematical training is a component of Informational and Educational Environment of the higher educational establishment. Slobodchikov defines IESM as "an open educational system formed on the basis of informational of educational resources, computer training facilities, modern means of communication, educational techniques aimed at guiding creative, intellectual and social development of personality", (Slobodchikov, 1997).

In the current study the term *informational and educational medium* for mathematical training refers to series of educational, information and communication material and technical conditions necessary for organization of educational informational interactions between students, teachers and ICT, as well as for developing of selected components of the mathematical training for future engineers of Art Materials Processing Department, (Pushkaryeva, 2013).

IESM Components

In accordance with aforementioned definition of IESE for mathematical training of Art Materials Processing Department bachelors at technical higher educational establishment the following components were allocated as:

- **target component,**
- **informative component, informational and**
- **communicational component, resource component, technological and performance components (Figure 2.).**

Mathematical training in schools and colleges of education have the same main objective that can be formulated as the development of basic mathematical knowledge and skills required for educational, practical and professional activities, and laying the foundation for development of mathematical skills, i.e. competences, and formation of a systemic and intuitive thinking needed for different activities.

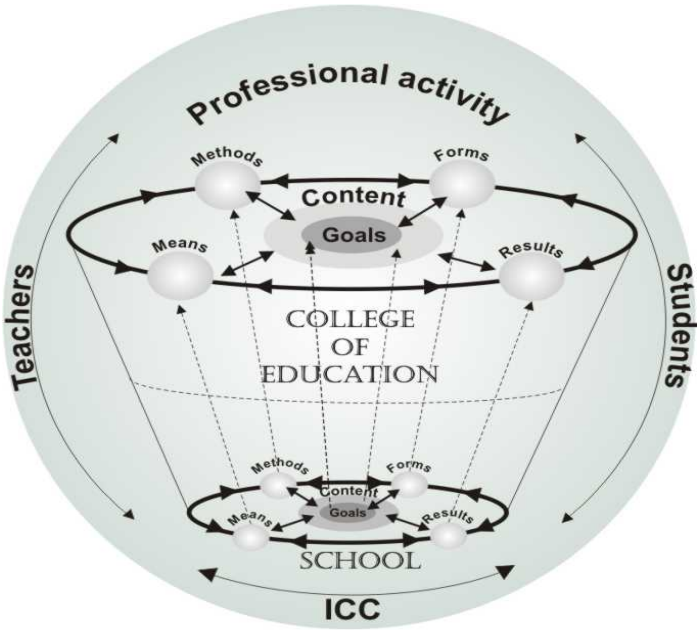

Figure 2.
Informational and Educational Subject Medium for Mathematical Training
(Source: Pushkaryeva, P. T. (2013). *Scientific and methodical bases of training in mathematics of the natural sciences future teachers from the information approach position*, monograph, Krasnoyarsk, Russia)

This goal includes a group of integrated goals of mathematical training for schools and colleges of education with due regard to FSES HVE requirements for students of Art Materials Processing Department at technical higher educational establishments and FSES requirements for secondary (full) basic education:

- **organization of mathematical training process in accordance with modern achievements of science;**
- **intellectual development of students trained with the use of principles of mathematics as a science;**
- **acquisition of specific mathematical knowledge, skills and abilities, that can be applied in practical and professional activities, will help students during the course of studying related disciplines and allow to continue their education process;**
- **personal development during the course of obtaining mathematical skills and participating in mathematical activities;**
- **formation of general overview about existing ideas and methods in mathematics, about mathematics as a form of description and method of understanding reality; as well as expansion of main objectives from the standpoint of informational approach to learning mathematics:**
- **development of mathematical thinking and mathematical intuition;**
- **training of mathematical modeling,**
- **development of skills for using ICT potential.**

Content selection for mathematical course is carried out in a hierarchical manner starting from the conceptual, "intuitive" level, followed by enhanced studying of the discipline. This method provides succession and continuity of mathematics content. Introduction of Mathematical Modelling section in the content of mathematical course provides a link between mathematics and vocation-related subjects, which increases the level of understanding of abstract mathematical concepts and promotes interest in the discipline.
Furthermore, the basic knowledge of mathematical modeling provides additional opportunities for students to choose a direction for further scientific research (course paper, graduation paper, master course, postgraduate training program etc.) and professional activity.

Information and communication component defines the relationship between participants of educational process. According to I. V. Robert these relationships involve interactions of students with teachers, fellow students, resources with the help of ICT (I. V. Robert, 2008). Such type of relationship structure provides for students active approach to the learning process and implements impact of each component of IESM and ICT on other components.

Resource component comprises:

- **educational learning materials in electronic format (mathematics textbooks, study guides integrated mathematical-profile courses, workshops, a list of topics for projects, a set of vocation-related tasks for mathematical modeling);**
- **software (spreadsheets, mathematical calculation software and integrated field-specific mathematical analysis software packages, programs for mental maps construction, Internet access);**
- **training system (electronic encyclopedia, complex tasks for mathematical intuition development);**
- **academic performance rating system (tests to identify the level of development of mathematical competence and mathematical modeling skills);**
- **material support of educational process (university laboratories and students' computing tools which is used for training).**

Technological component combines methods, means and forms of teaching mathematics to students of science faculties which contribute to development of selected mathematical training components.

The choice of methods and means of education is determined by targets of learning process at every stage of continuous process of student's mathematical training. Main selection criteria are static and dynamic visualization of mathematical concepts and computation layouts.

In accordance with education process objectives and special aspects of students' development all the components of IESM are theoretically designed and then practically simulated: resource potential, technologies, information and communication interaction between participants of educational process.

Intention, structuredness and productivity are quality criteria of IESM. Intention can be expressed through a system of indicators characterizing quantity and quality of system resource potential; structuredness is expressed through easiness of navigation and level of user friendliness of these resources; and productivity is expressed through the system of object, metaobject and personal results.

Level of mathematical training diagnosis from the standpoint of informational approach involves determining the level of mathematical knowledge and acquired skills of mathematical modeling.

Implementation of IESM for Mathematics Training of Art Materials Processing Department bachelors

We used Moodle distance education system (Modular Object-oriented Dynamic Learning Environment) to construct IESM for mathematics training for future engineers of Art Materials Processing Department on the basis of Polytechnic Institute of the Siberian Federal University (SFU) facilities.

Moodle is a course management system (CMS), also known as Learning Management System (LMS) or Virtual Learning Environment (VLE). This is a free web application that provides an opportunity for teachers to create effective on-line pages. Moodle modular Object-oriented Dynamic Learning Environment is focused primarily on organization of interaction between teacher and students, organization of distance learning courses, as well as support for full-time study.

Moodle distance learning system is installed on SFU server. It is available to any authorized user anywhere and at any time, making use of the learning environment comfortable for both teachers and students in all modes of study. Following roles can be used in Moodle:

- **administrator (can do everything online in every course);**
- **creator of the course (can create a course and teach within created course);**
- **teacher (can do a lot of things within the course, has access to editing section of the course);**
- **teacher without the right to edit course (can teach students, evaluate their level of knowledge);**
- **student (has access to course materials);**
- **guest (can have access to some of the courses in case guest access function is active).**

As mentioned above, the main component of IEE is IESM used for mathematical training of future engineers of art material processing faculty.
The main objective of IESM is shaping selected components of mathematical training. The necessary condition for mathematical training using IEE and IESM is the availability of computer class for practicing mathematics with access to network technologies.

Mathematical training using IESM implies a number requirement that has to be fulfilled by students:

- **understanding importance of IESM training for further education and development;**
- **ability to perform tasks according to instructions unattended;**
- **ability to find all necessary additional information on the Internet;**
- **ability to work in IESM complete and formalize tasks in a correct manner;**
- **ability to work in cooperation with other participants;**
- **knowledge of and compliance with the rules of behavior in eLearning environment;**
- **awareness of copyright rules and laws related to the distribution and use of digital content;**
- **ability to formulate questions and seek the help of course leaders and fellow students in case of arising difficulties;**
- **ability to assist other participants in training, to advise them on the use of ICT tools to formalize their work;**
- **compliance with the rules of competent writing when making requests to IESM.**

Organization of continuous mathematical training implies not only mathematical content selection for different levels of the course, but, above all, mathematical activity, because it is mathematical activity that can be vertical and continuous. Vertical model of mathematical training is realized directly at the expense of engineering research activity, as soon as it is based on the "lower level" on existing mathematical knowledge and knowledge of other disciplines and is directed "upward" for further subject-oriented training.

Under the term *mathematical activity* we understand mental activity aimed at mastering mathematics, providing the ability to expand the knowledge, perceived or created by subject. The main types of;

- **mathematical activity that we have identified are,**
- **educational activity and**
- **informative activity, engineering research activity and self-directed learning activity.**

The process of training and development of mathematical knowledge, mathematical problem solving and mathematical modeling skills are achieved by Galperin's gradual formation of mental activity method application, as well as by application of problem solving and engineering research methods.

The traditional means of teaching are supplemented by electronic media resources, mental maps, simulators and interactive tests.

Mental maps and Flash-animation are used as *main imaging and data compression techniques* together with educational material presentation as a single super positional content. Mental map is the way of depicting thinking and structuring information processes in a visual form that allows a person to manage the information flow (Novak, 1990, 2002). Outwardly, it resembles interrelated brain neurons. It provides perfect match between visual perception and basis behind the construction of this information.

The advantage of such maps is in the ability to see the whole picture on one sheet with all interrelations, structure and logic behind it (Kalitina and others, 2015). This method helps to provoke more active functioning of the right hemisphere of the brain, which is usually inhibited, increase the level of intuition, type of thinking process localized in this hemisphere (Figure 3.).

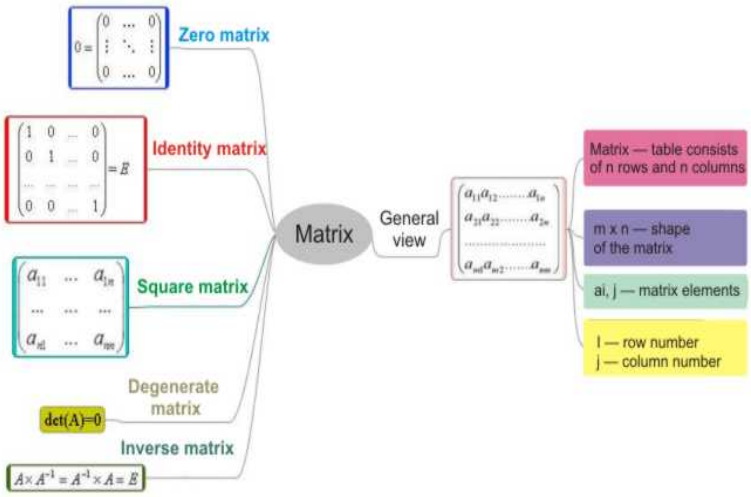

Figure 3.
Example of mental map (Source: Tatyana P. Pushkaryeva, monograph)
(Source: Pushkaryeva, P. T. (2013). *Scientific and methodical bases of training in mathematics of the natural sciences future teachers from the information approach positions*, monograph, Krasnoyarsk, Russia)

Mental maps drawing process helps to develop not only logical but creative thinking and achieve memory and imagination training. Mental maps constructing method is based upon functioning of two hemispheres of the brain, in contrast to method of linear recording (Zdenek, 1997).

A special program was developed to train skills of mathematical modeling which is used to visualize some of subject oriented concepts of "Basics of casting process" course for Metallurgy Department, Foundry Production Of Ferrous And Nonferrous Metals specialization (Figure 4.) (Gilmanshina and others, 2012).

This software allows you to analyze and compare the different parameters of a mathematical model, such as wetting qualities of material under the influence of different liquids, as well as to calculate basic indicators (wetting quality contact angle, work of adhesion, spreading coefficient, etc.).

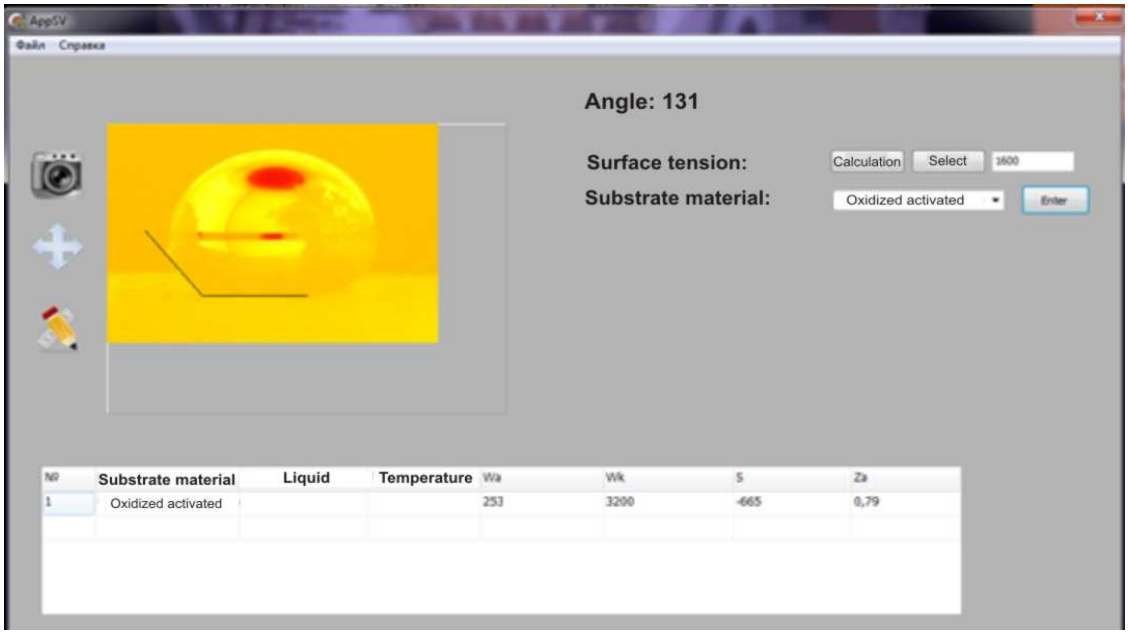

Figure 4.
AppSV interface
(Source: Gilmanshina, T. and et.al. (2012).Computer state registration certificate) (2012). (Computing program of studying of wettability of materials liquids «AppSV», Krasnoyarsk, Russia)

The results evaluation unit **includes three levels of mathematical training criteria and indicators for future Art Materials Processing Department engineers: basic, competent and creative. Level of mathematical training is based upon total score. Special system was created to allow for tests with three-level tips in accordance with mental maps structure.**

RESULTS

Pedagogical experiment of mathematical training for future art materials processing engineers revealed that types of IEE and IESM, developed for mathematical training, provide an increase in levels of mathematical knowledge of bachelors due to:

- **unity of goals of mathematical training process;**
- **continuity of content, methods, forms and means of mathematical training process;**
- **ensuring continuous mathematical activity;**
- **a set of special training means and methods (mathematical training courses integrated with vocation-related subjects, mathematical modeling method, dynamic visualization of mathematical information method, system dynamics, universal means of control and diagnostics knowledge);**
- **informational "subject-object-subject" interaction of educational process participants.**

The results of the questionnaire survey for of Art Materials Processing Department engineers, as well as some evaluation results of the training process, revealed that mathematical training using IEE increases motivation, mathematical abstractions perception level due to taking into account psycho-physiological characteristics of students, training classes attendance rate, increases percentage of extracurricular self-study activities and level of knowledge not only in mathematics, but also in vocation-related subjects.

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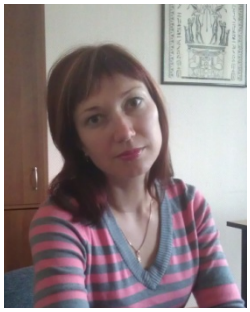

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