Professional training of the future computer science teachers and lecturers by the means of the course "Computer geometry and graphics"

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ABSTRACT

State Program of the Russian Federation «Information Society (2011-2020)» and State Program for the Development of Education of the Republic of Kazakhstan for 2011-2020 define the tasks of one of the directions that requires serious and active modernization. This direction is the training of computer science teachers and lecturers by the means of the course "Computer geometry and graphics". The relevance of the researched problem is caused by the need for the implementation of the developments in the field of creating and improving of principles of modeling and designing of methodical system of training course "Computer geometry and graphics". The purpose of the research is to create in modern higher education institutions a modern methodical and material and technical base for the training and retraining of specialists for the ICT sphere, lecturers and teachers. And to develop a methodology aimed at improving traditional technologies of training of computer science teachers and lecturers by the means of the course "Computer geometry and graphics". The leading methods to study this problem are: system analysis to determine the methodological foundations for improving the content of the training of the future computer science teacher and the structure of professional competence; theoretical analysis of psychological and educational literature; content analysis of periodical press materials on the research problem; analysis and generalization of the pedagogical experience of the contents of the training of the future teacher of informatics; questioning, interviewing teachers, students, teachers, heads of educational institutions, the method of peer reviews; pedagogical experiment, etc. The practical significance is the creation in the institutions of higher professional education of a modern methodical base for the training and retraining of specialists for the ICT sphere, for training of computer science teachers and lecturers by the means of the course "Computer geometry and graphics".

Key words: Computer geometry and graphics, digital natives, information approach, flipped learning, informatization

INTRODUCTION

The systems of education throughout the world are undergoing reforming due to global changes in society, transformation of political systems and other socio-economic factors. The essence of management of development of the higher education system is to increase controllability and productivity of the higher education system in terms of methodological, organizational, content and technological transformations, which leads to
opportunities for the development of positive and reduce
negative consequences of education’s reforming (Levina
et al., 2016).

Socio-economic challenges of society, technological
breakthroughs determine new requirements; create new
possibilities, which significantly change the goals and
objectives of higher education. The creation of a unified
educational space in Russia, the widespread development
of information and communication technologies, and their
penetration into all spheres of society require the training
of specialists for the computer science sphere within the
framework of professional educational programs.
Preparation of these specialists is not possible without the
highly qualified faculty of universities and school teachers.
That is why it is necessary to create in modern higher
education institutions a modern methodical, material and
technical base for the training and retraining of specialists
for the ICT sphere, for the preparation of teachers and
lecturers of computer geometry and graphics. The modern
teacher should own knowledge not only the subject
matter, but have skills of search, selection and transfers of
the educational information in various forms, skills to
build mathematical models and to use the computer
technologies. Learned disciplines should be
interconnected, their unity and integrity are the necessary
conditions for the professional-pedagogical orientation of
training of future teachers of computer science (Nikitin
and Kolyago, 2014). Construction of information-
educational space provides performance of these
problems.

Currently, informatization has become a stage of
civilization development of society, opening many areas
and opportunities in all spheres of activities. In education,
informatization has gone the way from dissemination of
technologies, computerization of the educational
environment, changes in the forms of training to ”new field
of pedagogical knowledge” (Robert, 2012). It is the very
information and communication technologies has
triggered the development of a new content of education,
learning systems, educational resources, educational
environments, the proliferation of computer-based testing,
automation of management, changing the conditions of
realization of educational process and expanding the types
of educational interaction and educational opportunities
(Khodanovich, 2003; Pak, 2011).

However, the use of IT-technologies is not a sufficient
factor in improving the quality of education and the level of
progress achieved by the trainees, but it can be a good
helper in the course of the examination, automation of the
selected methods of control, as it is a more individualized
approach to learning (Kuprina et al., 2016). According to
Jaroslav Kultzan from Bratislava, the learning process,
objectives and ways to achieve them can be compared with
certain simplifications to a technical control system. One of
the main tasks of the control processes is to create a
proper feedback which can not only maintain the
controlled system in the sustainable state but also achieve
the desired result. As in the technical sphere, there are
developed different approaches to creating effective
feedback for linear and nonlinear systems and the learning
process is aimed at getting certain objectives to be
achieved within the given timeframe - the learning process
can be viewed as a system that has a lot of common
features with technical systems. According to Malcolm
Brown since education is the core mission of higher
education, learning and the space in which it takes place
are of the utmost importance (Brown, 2005).

In order to best serve the educational enterprise, we
must design leaning spaces that optimize the convergence
of the Net Generation, current learning theory, and
information technology. Besides now thousands of
students are taught CGG not through textbooks, but from
video lectures by scientists and researchers at Coursera,
EdX and others. All around the world interest in Flipped
Learning is growing among educators, school administrators, and education leaders (Bergmann and
Sams, 2014). Flipped classroom pioneers Jonathan
Bergmann and Aaron Sams take their revolutionary
educational philosophy to the next level in Flipped
Learning. Now they Build they theory on the energy of
the thousands of educators inspired by the influential book
Flip Your Classroom.

Given the urgency of the current problems of fuel and
energy resources, oil and gas industry, engineering,
instrumentation, chemistry, ecology, etc., in this article we
have made an emphasis on creating and improving the
principles of modeling and designing the methodical
system of the training course ”Computer Geometry and
Graphics” for the training of lecturers working in the field
of higher technical education. Engineering drawing impact
is one of the fundamental skills needed by all engineers to
be creative and productive in engineering profession
(Azodo, 2017). Errors made in an attempt to interpret
engineering documentation could pose some exigent
catastrophe to the whole essence of design and production
processes (Kosse, 2005). The implementation of modern
information technologies in engineering graphics
education provides a good foundation for the acquisition
of knowledge and skills which are necessary in
engineering practice (Cobos-Moyano et al., 2009). All
students in engineering discipline are taught engineering
drawing. This helps develop their spatial ability, design
competence and expertise needed for problem solving
prevalent in engineering profession. Along with the
evolution of computers, course content has moved on from
being pure manual drawing to a combination of manual
drawing and computer-aided drawing (Wang, 2011). In
order to take full advantage of the computational tools, e.g.
CAD, students should have a prior knowledge of
elementary concepts of geometry (Stachel, 1994).

A sufficiently large number of researchers now are in the
process of finding ways and means of improving the
geometric - graphic preparation. The basics of engineering
drawing are taught using a variety of approaches;
computer assisted teaching methods as well as traditional manual drawings (Ignatova et al., 2015; Surinkova, 2014; Heifetz, 2016; Kondo et al., 2005; Voronina et al., 2016; Voronina and Tretyakova, 2017; Voronina et al., 2016; Moroz et al., 2016; Tretyakova et al., 2016; Folomkin et al., 2016; Voronina and Tretyakova, 2015; Voronina et al., 2016; Moroz et al., 2016; Tretyakova and Voronina, 2016; Merkulova, 2012; Merkulova, 2015; Merkulova and Tretyakova, 2015; Merkulova, 2016; Voronina and Moroz, 2017; Folomkin and Voronina, 2017). Methodological knowledge is necessary in the construction and organization of the educational process, being closely connected with the methods, methods of pedagogical activity and, of course, the personality of the teacher himself, his professional knowledge, skills and professional creativity, as well as modern requirements of society and the labor market. From all the variety of factors that lead to problems in teaching, in this article we will consider the teacher’s approach to teaching students, the informational approach to the management of higher education's development, the atmosphere of learning, learning spaces, the motivation and attitude of students to learning. The results of the research will be useful for professionals involved in professional training of the future computer science teachers and lecturers by the means of the course "Computer geometry and graphics".

MATERIALS AND METHODS

Research methods

During the study following methods were used: – Theoretical (analysis, synthesis, concretization, generalization); – Empirical (the study of the regulatory and educational-methodical documentation of engineering universities of Russia, literature review, pedagogical supervision); – Experimental (notes forming, controlling). – Technology Road mapping (specific method of scenarios - creating a visual representation of the plan-scenario development technology, which captures the possible subjects and critical decision points).

Experimental research base

The studies were conducted on the basis of the St. Petersburg Mining University.

Stages of research

The studies were conducted in three phases:

1. At the first stage, a theoretical and exploratory analysis of existing methodological approaches in the scientific literature was carried out. The analysis of scientific-pedagogical and psychological-pedagogical literature on the stated problem was carried out; scientific-methodological approaches to the research were specified. We analyzed dissertations on issues, literature review, as well as the theory and methodology of educational research; highlighted the purpose, research methods, made up of experimental studies. At this stage of the research, the following methods were used: analysis of philosophical, pedagogical, psychological and scientific methodological literature, modeling of the educational process and inversion of the model of the educational process in the components of the teaching methodology.

2. In the second stage experimental work was carried out; the findings obtained in the course of experimental work and research of the plan-scenario development technology were analyzed, tested and refined. The choice of theoretical and methodological approaches to the construction of the model of computer graphics training methodology was substantiated, the components of the teaching methodology were developed, the set of pedagogical conditions for the implementation of the model of CGG training methodology for students was formulated. In the course of the study of conclusions, the introduction of research results into the practice of the work of higher education. At this stage of the study, the following methods were used: analysis of pedagogical and scientific-methodological literature, generalization of pedagogical experience and mass pedagogical practice.

3. In the third stage, summarizing, the analysis was carried out. The experimental work has been completed, theoretical and practical conclusions were clarified, and the results were summarized and systematized. Generalization, systematization and final processing of the results of the pilot work were carried out, the conclusions and recommendations were clarified, the methods used were comparative analysis of the results of the control tasks in the training groups, analysis and processing of the results of the pilot research using methods Mathematical statistics, methods for presenting research results.

MODEL OF TEACHING METHODOLOGY

In the course of the research, a model of the teaching methodology for training of computer science teachers and lecturers by the means of the course "Computer geometry and graphics" has been developed.

In modern conditions, the importance of quality teaching of CGG for computer science teachers is determined, first of all, by the fact that the study of discipline activates the processes of development of cognitive abilities, spatial imagination, and also some personal characteristics of trainees.

Under the technique of teaching computer graphics, we mean the organization of the process of studying the disciplines of the field CGG (a set of principles, content, methods, tools and forms). This technique is aimed at
activating creative activity and taking into account individual preferences of the trainee, forming the willingness of a specialist to solve professional tasks in the field of computer graphics and pedagogical preparation. The object of the method of teaching computer graphics to university students is the process of learning CGG in certain special conditions that impose an imprint on the objectives of studying the subject, the content of training, methods and forms of organization of educational and cognitive activity, monitoring and correction of learning outcomes.

Unlike the already existing and well-known models of flipped training, we offer our own learning model in which several models are combined five models in one unit. So, our model of the teaching methodology is based on:

1. The concepts of «Flipped Class» model with feedback and its implementation in the learning process with the use of modern information and communication technology (Bergmann and Sams, 2014).
4. The model of «Learning management system», proposed by Professor Jaroslav Kultan from Bratislava, Slovakia (Kuprina et al., 2016).
5. The model of informational approach to the management of higher education’s development of Levina et al. (2016).
6. The methodological model of «Computer graphics training for university students» of Professor Tatjana Viktorovna Chernyakova from Ekaterinburg, Russia (Prensky, 2001).

FLIPPED CLASS

The Flipped Class (inverted class) is a learning model in which doing homework, among other things, involves the use of Pre-Vodcasting technology. While there is no one model of "flipped classroom", the core idea is to flip the common instructional approach. Our model is an educational method, in which:

1. Lecturers create Pre-Vodcasts (video-on-demand) of his lectures (video lecture, training texts, review of explanatory drawings, passing tests on the initial mastery of the topic).
2. Students get an idea of the topic before the class at which this topic will be considered.
3. The classroom time, when a teacher is nearby, is used for joint implementation of practical assignments. Classroom work is devoted to the analysis of a complex theoretical part and questions that the students have in the process of doing homework. In the class, students under the supervision of the lecturer carry out research tasks or solve practical problems.
4. After classes in the classroom, practical tasks and tests for understanding the passed theme are completed.

New learning spaces

Over the past 20 years, higher education has invested millions of dollars in classroom technology. The Internet access, projectors, etc. make possible to devise new types of classroom activities for students, network connectivity is increasingly portable now. This means that learning can occur anytime and anywhere. The concept of the classroom has expanded; virtual space has taken its place alongside physical space. We can now integrate the lecture hall with other spaces, physically and virtually. These new integrated classrooms capabilities have sparked interest in new pedagogical approaches, to develop new and more effective pedagogies, to teaching methodology for teachers of computer science; including by the means of the course "Computer geometry and graphics" has been developed. Wireless networking, for example, allows discuss of topics in real-time. We can real-time polling among all class participants with synchronous interaction of students. Videoconferencing makes it feasible for an invited expert from a remote institution to join a class session. These approaches well mesh with the habits of students (Brown, 2005).

But you should begin with an underlying vision for the learning activities these spaces should support, institution's specific culture, organizational structure, and institution's fiscal circumstances enter the equation, as well. If the vision has been established, the more concrete phases of planning can begin.

Learning spaces should accommodate the use of as many kinds of materials as possible and enable the display of and access to those materials by all participants. Learning space needs to provide the participants— instructors and students alike—with interactive tools that enable exploration, probing, and examination (Brown, 2005). And, of course, learning does not stop once the instructor and students have left the classroom. The end of the class marks a transition from one learning mode to another. Unfortunately, the task of designing and implementing learning environments that encourage good learning practice and accommodate the learning style is a challenging one.

Net generation

It is a new methodology with using IT-technologies explaining the new educational material, promoting the audience's motivation, which is especially important with increasing the motivation of young people with new technologies and their capabilities, without which they cannot imagine their existence.

In 2001, Marc Prensky wrote in his famous work "Digital
Learning management system

The learning process is aimed at getting certain objectives to be achieved within the given timeframe. We propose to consider the learning process as a system that has many features in common with technical systems. It is known that in the process of the machine or person’s control, one must set a goal of the activity, check the process of goal achievement and strive to achieve this goal. The technical and educational systems are quite similar. During the process of achieving the goal one needs to change the input value of the controlled system in the case of deviations from the intended goal. The main task of the control theory is the selection of the successful impact on the system. In technology, there are many methods of selecting the correct impact to preserve sustainability and achieve the objectives (Kuprina et al., 2016).

In our opinion, the role of feedback is to provide information on the knowledge level and understanding of new material directly in the learning process. Now lecturers have the opportunity to change the ways and methods of their work, they can explain incomprehensible for student topics in more detail or not to spend time on something that is already known to everybody.

### Information approach in education

Application of the information approach in education are very wide: from didactic forms and means, based on information and communication technologies’ possibilities and information systems’ modeling of artificial intelligence, providing training and management. The use of IT-technologies in teaching not only facilitates the work of lecturers, but also has an impact on the learning process. The ability to quickly find the necessary information, the possibility of rapid communication between the participants of the educational process can lead to a change in the learning process. The ability to implement multiple types of feedback can also lead to changes in the learning process and delivering lectures (Levina et al., 2016). Thus, the information approach is defined as the leading one in research and is considered as the objective possibility to reduce uncertainty through the higher education system (structure, process and phenomenon) in the form of information field containing all the information for its development.

### METHODOLOGICAL MODEL

#### The main didactic questions of our methodology

The main didactic questions dominate in our methodology: why teach, what to teach and how to teach? The first question relates to the meaning of learning, the second to its content, the third to the forms and methods of teaching. These questions make up certain educational technologies. In the methodical work of the teacher, two levels are distinguished: empirical and theoretical. The lecturer
should not only know the contents of his discipline, but also to own methods and techniques for the formation of knowledge and professional skills.

The empirical level means to show the system of actions, operations, methods of organizing the educational and cognitive activity of students in the formation of knowledge and skills. At the empirical level, the teacher and lecturer masters the process of teaching his subject, methodological methods, creates methodological developments in his discipline, tests visual aids, improves logistical support of the classes.

At the theoretical level, the teacher generalizes and transmits methodological experience to fellow teachers. The methodological work of the teacher turns into professional methodological activity, the subject of which at the theoretical level are regularities of related sciences, refracted in the methodology, peculiarly expressed patterns of didactics, methodological regularities, methods for creating and constructing of teaching and technologies, that have signs of relevance, novelty, systemic, instrumental, reproducible and effective in teaching practice (Folomkin and Voronina, 2017). The theoretical level is abstracted from the personality and practical activities of the teacher and the most valuable findings of the teacher are summarized. The generalization of the practical activity of the lecturers allows us to find the shortest and most accessible way of transferring the teaching material from the lecturer to the students. And we should describe this path in the methodology of teaching the educational subject matter.

Since the introduction of the computer graphics course to higher educational institutions, lecturers have accumulated a teaching experience, but the didactic teaching system of the course has not yet formed finally. Besides modern computer graphics area is dynamic and a fairly broad field of scientific knowledge, covering methods, technologies and tools for creating computer 2D and 3D images of various types, as well as interactive and animated products. New consumers of computer graphics are constantly appearing, new qualified CGG engineers and developers of computer models and presentations are required. In connection with the development of information technologies, most new specialties appeared in the field of computer graphics. Of course, this should all be reflected in the content of the discipline.

Levels of methodology

Our model includes motivational and target levels, axiological, procedural and reflexive assessment levels:

1. The motivational and target level of the model includes the preparation of a competitive specialist who has the appropriate professional competencies and can achieve, through the possession of methods for solving of professional tasks, the set professional aims in different, rapidly changing situations.
2. The axiological level of the model is focused on the system of values and attitudes to the application of CGG in the future professional activity.
3. The procedural level of the model includes the principles, methods, means, forms of organization of the process and the pedagogical conditions for their implementation.
4. The reflexive-evaluation level of the model determines the willingness of a specialist for future professional activities in the field of computer science. It is determined by the following ratings: excellent, good, satisfactory.

Block-modular basis of the methodological support of CGG

Methodological support of CGG is based on a block-modular basis. It includes the following blocks: theoretical studies, propaedeutic and methodological blocks, practical exercises, independent work, control:

1. The theoretical block is implemented by us in the form of electronic textbooks and presentations. It includes consideration of the basic aspects of computer graphics: definition and main tasks, the history of development, types and areas of application of computer graphics (Koutropoulos, 2011). The modular structure presupposes a Multilevel structuring of the teaching material, the basic level, which determined by the content of the state educational standard. And some advanced levels, which allows designing individual trajectories of trainees.
2. The propaedeutic block includes recommendations for studying the standard formats of image storage in raster, vector and fractal graphics with a focus on the concept of compression algorithms and of image formation.
3. The methodical block includes State standards, curriculum, schedules of independent student’s work, working programs, methodical instructions for the lecturers on conducting theoretical studies, laboratory works, and the organization of distance learning.
4. In the practical block, the trainees carry out training project by a set of techniques in their specific sequence to achieve the task. The trainees should find a solution of the problem personally significant for them and designed in the form of a certain final product. For example, having received the technical assignment in accordance with their specialty and the direction of preparation, they develop 2D working drawings of the parts included in the assembly unit, 2D assembly drawing with specification, 3D models of the parts included in the assembly and 3D model of the assembly unit.
5. Self-taught work is conducted by an intern as part of a block of independent work in parallel with the study of theory and is one of the control points. For example, an intern should not only develop and create a 2D assembly drawing of an assembly unit with its 3D-model and a
specification, but also visualize the project, select the materials of the parts included in the assembly, illuminate, and to prove the importance of the project. Self-study projects are also included in the learner's portfolio.

6. The control unit contains the criteria for assessing practical classes and tests of the theoretical material. Evaluation of students' projects consists of several stages: visual viewing of the project, listening to the student's comments to the project and answers to the teacher's questions. We have developed several forms with an approximate form of theoretical questions in accordance with the selected level of trainee training for the convenience of the lecturer's work.

CONCLUSION

Concluding the article, we would like to state that nowadays:

1. The development of informatization gave us an opportunity to talk about the achievements in the field of education.
2. The dissemination of computer networks and the use of their capabilities in education has given rise to new types of education and into forms of control.
3. It allows us to create the information space of the educational organization by creating a learning and education environment.
4. The development of informatization lets us to change in didactics, development of new tools and methods of teaching, knowledge control technologies.
5. It gives us new opportunities for differentiating of educational material on the basis of psychophysiological characteristics of students.
6. And it lets us to changes in organizational management systems in educational institutions.
7. The functions of information accumulation provide statistics of data taking into account and storing information about educational processes.

The developed model of computer graphics training methodology is successfully applied when teaching students computer graphics and can be recommended for various specialties. The description of our methodological model is suggestive rather than prescriptive. Methodological model are complex, containing a multitude of variables. Our study proposes recommendations for coordinating designs of teaching materials in other courses. One of the key variables is the institution itself. The implementation of learning spaces and our methodological model involves the institution's culture, tradition, and mission. Learning space design is a large-scale, long-term project, involving building and maintaining consensus, curricular vision, emerging technology, and layout and furniture options, as well as intercampus organizational collaboration. Learning space design requires a collaborative, integrated approach, with an overarching vision that informs and supports specific projects (Brown, 2005). These factors must be taken into account in order to design learning spaces and to create methodological model of teaching with remember and understand that soon today's students will be graduate students and assistant professors.

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