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A SUBSTANTIATION OF FORESIGHT RESEARCH OF DEVELOPMENT STRATEGY OF DESCRIPTIVE GEOMETRY, ENGINEERING GEOMETRY AND COMPUTER GRAPHICS DEPARTMENTS ON THE BASIS OF INDUSTRIAL 4.0 IDEOLOGY

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The relevance of the problem stems from the fact that due to the introduction of modern, efficient CAD systems and other technologies together with Industry 4.0 is necessary to reconsider the concept of the methods of teaching Descriptive Geometry, Engineering Geometry and Computer Graphics worldwide and also to adjust its content and load balancing. The article describes findings of first part of our research, containing principles, that in our opinion should be considered into large-scale Foresight researches of development strategy of «Descriptive Geometry, Engineering Geometry and Computer Graphics» departments, which focuses on geometric-graphic component of the concept of engineering structuring, including interdisciplinary approach combined with modern trends in the development of modern CAD technology based on the ideology of Industrial 4.0. The purpose of this study is to introduce to the educational process the integrated information technology on the basis of existing CAD and to create a simple and clear way from technical drawing fundamentals through advanced CAD technology to the complex geometry within the concept of Industrial 4.0 to help students to understand how to apply their knowledge in the future. The leading method to study this problem is the foresight method, which allows us to engage the social forces in the discussion and comparison of long-term forecasts, the development of strategies, development of an integrated vision of the future and agreeing ways to achieve it. The study aimed at adapting of lecturers to the new conditions professional work in the field of education, the integration of professional psychological and pedagogical training of lecturers. It focused on the development of scientific and methodological support of the decision of psycho-pedagogical and organizational-methodological problems of teaching Descriptive Geometry, Engineering Geometry and Computer Graphics around the world.

Keywords: Descriptive Geometry, engineering geometry and computer graphics (DG, EGCG); computer-aided design (CAD), foresight research, Industrial 4.0, lecturers.

INTRODUCTION

The idea of developing the first CAD in mechanical engineering was to eliminate the chore work. It is known that the share of routine work, related to the need to manually release the technical documentation (the designer drew a pencil on the drawing board, the technician filled out a forms of every possible card in ink) was higher than 80% (Balyakin, Ermakov & Chempinsky, 2011). Globalization, hyper competition, complicated demographic situation, on the one hand, modern achievements of science, increasing the share of multi-disciplinary research, the

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rapid development of high technology and complexity, on the other hand, had a major impact on the changing role of the engineer in the high-tech industry and society (Borovkov, 2012). The rapid development of information and communication technologies for the past 30 years has led to a significant change in the content of engineering works. This caused a change in the requirements for graduates of higher engineering and technical universities and regular development of new approaches to the assessment of his professional qualities.

On the one hand new technologies have introduced many facilitating methods and approaches and on the other hand they have made the transfer of information much faster which is at times not in accordance with traditional educational theories. The introduction of CAD technology in technical departments has especially affected the world-wide methods of teaching geometry (Stavric, Wiltsche & Schimek, 2005).

Currently Engineering geometry and computer drawing emerged as a science and technology area, dedicated to the development of theoretical foundations and practical methods of geometric modeling phenomena, objects and processes in nature, art, technology, economics, construction and architecture. And the solution of scientific and applied tasks aimed at achieving optimal parameters of geometric models of phenomena, objects and processes, providing the most complete account of functional, structural, technological, economic, aesthetic and other requirements.

With the rapid development of the IT industry and infrastructure of the information society, we should not stop; we must continuously develop the national system of engineering education in all its forms, which conform to international standards, covering all types of professional training of technical personnel. The exponential growth of knowledge, combined with a reduction in terms of updating information in the professional fields, the innovative nature of the economy requires the extensive use of modern ICT in all spheres of activity (Suhomlin, 2008).

So, we are confident that it is necessary to create a multi-level system of training with the use of modern high-efficient electronic media, including CAD / CAM-software. Any system of knowledge in the learning process should promote the formation of students' active and constructive technical positions, system design and engineering world.

Student's information subsystem evolves throughout the entire period of study at the university. The learning environment provides professional improvement of mental functions of the student, if its design takes into account the conditions of a harmonious connection stages and levels of learning (Ivaschenko, 2009).

Thus, continuously and rapidly developing information and communication technologies have a significant impact on the development and improvement of the learning process. From engineers theoretical knowledge and practical skills are now required to solve production and management problems. In addition, the engineer needs to navigate freely in the flow of scientific and technical information is constantly updated their knowledge, to anticipate trends in the development of science and technology. He must be able to think creatively, to defend their point of view. The basis for the formation of these qualities must be technical universities. In addition, the Department of DG, EGCG must constantly adjust and immediately begin to implement advanced technology training, not forgetting the classical descriptive geometry, certainly forming spatial thinking of the future engineer.

Implementation of modern information technologies in educational process of higher education is one of the priority directions in the problem of improving the educational level of the students (Nesterenko, 2004).

Despite national differences in the approaches to the Foresight, there are several basic principles of this new method. Our Foresight research has the following objectives: assessment of the specific scientific and technological areas; of the prospects of science and technology; of scientific and technological development prospects in the socio-economic context.

The article describes findings of first part of our research, containing principles, that in our opinion should be considered into large-scale Foresight researches of development strategy of DG, EGCG.

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 Roadmapping (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:

- In the first stage a theoretical analysis of the existing methodological approaches in the scientific literature was carried out. 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;

- 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;
- In the third stage the experimental work has been completed, theoretical and practical conclusions were clarified, the results were summarized and systematized.

RESULTS

The influence of CAD technology on the DG, EGCG

CAD-technologies are used in a variety of industrial factories and for the training of students at technical universities almost everywhere since 1990 and until now. In recent years, the number of systems CAD / CAM / CAE and information technologies has increased significantly. Currently, CAD is a common tool used in the process of designing, design documentation and construction for modelling and drawing, and generally throughout the entire design process (Surynkova, 2014).

But developers and manufacturers of many CAD brought the situation to the fact that, firstly, users are faced with the problem of choosing the complexity of the system for their work. Second, many users and developers of CAD themselves faced with the problem of incompatibility of growth of solutions offered by multiple information technology systems, including CAD / CAM / CAE - systems.

Currently, there is a massive and widespread transition of the educational process in the engineering education towards modern information technologies. This reform of the educational process is carried out by introducing into the curriculum of new subjects related to the use of information technologies. The leading technical universities in the world go ahead and often open new specialties and introduce new subjects. So they often have a goal of making the scientific and technical progress. To carry out this process are advanced learning technologies, including the introduction of the activity approach system with the release of closed training units (modules), which are subordinated and interlinked to each other, and directed to solve the problems and the formation of special and specific types of activities. The methodology of the system approach allows us to represent the active learning process as a well-planned system of assimilation of students teaching and professional activities.

In recent years, there is a special branch of information technologies - knowledge engineering, aimed at the study of problems of presentation and use of knowledge. Engineering knowledge is an "area in the theory of artificial intelligence that deals with the languages for knowledge representation, methods of updating knowledge, inspection procedures of their accuracy and consistency, and finally, the use of knowledge in solving various problems and the creation of practical systems for the storage and processing of knowledge" (Kakhkharov, 2015).

Unfortunately, already by 1990 in the syllabus of the courses in the field of EGCG and DG the content in the field of geometry was reduced - we may even say minimized. Hellmuth Stachel from Institute of Geometry, Vienna believes that it happened mainly due to a misunderstanding regarding the syllabus of descriptive geometry and its constructive technique by using drawing equipment. Descriptive geometry was neglected although it is the only discipline at the technical departments which teaches future engineers to communicate with one another by means of drawings and also the only discipline which trains visual spatial intelligence (Stachel, 1994). Reduced instruction in geometry at the universities has initiated a number of enquiries worldwide. On the basis of the UNESCO recommendations on education reform scientists conducted a lot of research in this area.

Later, having analyzed all the previous research George Kospentaris and Panagiotis Spyrou from Department of Mathematics, University of Athens, Greece proved in their research that there was a direct connection between the study of the subject matter of descriptive geometry and the improvement of visual spatial intelligence - as one of the most important ability for an engineer (Kospentaris & Panagiotis, 2010).

In addition, Constantin Volkhin, Tatiana Astakhova from Novosibirsk State Universities proved that the use of computer technology for the design drawing allows the use of modern means of communication between students and lecturer. Students are used to do it to get advice on work or presenting it to the lecturer, to check that activates the educational activity, increases its efficiency (Volkhin KA, Astakhova, 2012).

Thus, we believe that the personality of the engineer is only possible in combination of his theory knowledge of the classical methods of DG, EGCG standards and CAD software systems, which, in our opinion, is a modern tool for the implementation of geometry problems. But with the use of modern means of communication between students and lecturer on the basis of CAD-technologies.

Module of CAD-systems should be an integral part in the study of basic engineering disciplines, which are the basis of graphic technical training at the Technical University: DG and EGCG. Possession of CAD-systems - is an integral part of the professional competence of the modern designers and planners. Integration of CAD-systems in the process of teaching subjects, in any case, not excluding the classical methods of teaching descriptive geometry and engineering graphics in the first year, long-term testing of the past in our department. The difference of our methodology is in the use of CAD-systems during lectures, practical and laboratory classes with duplicating on the first semester the "manual" method of homework performance with tasks in CAD-systems. Since on the one hand, the classical methods of teaching descriptive geometry perfectly develops spatial thinking of the future engineers. On the other hand if students are not trained CAD design and modeling in the first and second semester of the first course, and start to get acquainted with CAD-systems only as senior students within specialized disciplines, it takes them and their lecturers from specialized departments precious time.

As a result of the first part of our research we came to the conclusion that the first principle, which should be the basis for subsequent foresight studies DG, EGCG departments should be the principle of student learning, which combines immediately with the first semester the strategy of the mandatory teaching by both ways in the same time. Foremost, training students classical methods of solving problems of descriptive geometry, which necessarily involves training projecting objects in different octants space, finding traces of geometric objects and methods of objects' conversion. Secondly - training students to work in a modern CAD system.

Modern technologies and principles underlying the DG, EGCG

The founder of the so-called common information space can be regarded to the United States, where, under the auspices of the US Department of Defense since 1985 actively implemented in stages Computer-Aided Acquisition and Logistics Support (CALS). Initially CALS - is an automated supply system of support, research supervision and management and development in the field of military technology, organization of production, maintenance, and provision of spare parts. This system includes a set of standards, the common feature of these standards is the principle of single data entry and multiple uses of it, paperless information technology transfer between local integrated data base.

Later CALS concept began to be applied actively in all spheres of industry, gradually and actively expanding and covering all stages of the product lifecycle.

Currently, CALS - this Continuous Acquisition and Lifecycle Support, it is a continuous supply information support and life cycle of products. That is an approach to the design and production of high-tech and science-intensive products, which consists in the use of computer technology and information technology at all stages of the product lifecycle, from marketing research to disposal and recycling.

At its core, CALS is a global strategy for increasing the efficiency of business processes performed during the life cycle of the product due to information integration and continuity of information generated at all stages of the life cycle. The possibility of sharing information is determined by the use of computer networks and the standardization of data formats, ensuring their correct interpretation.

CALS-technologies enable the company to create an effectively operating computer product quality management system conforming to the international standards ISO.

PDM-system of modern production management, it integrates the information in any format and type, coming from different sources, providing its users in a structured way, tied to the characteristics of modern industrial production. PDM systems generalize such well-known technologies such as management of engineering data (Engineering Data Management - EDM), document management, product information (Product Information Management - PIM), management of technical data (Technical Data Management - TDM), the management of technical information (Technical Information management - TIM), image management, and so forth.

Any information needed at a particular stage of the product lifecycle, can controlled PDM system that provides the correct data to all users and all industrial information systems by monitoring the actual product information about the state of the data objects, the approval of the changes, performing authentication and other operations which affect the product data and modes access to each user.

PDM system is a mediator between new products' design stages and MRP system (Manufacturing Resource Planning).

Integrated CAD occupies the intermediate position between-MPR systems and CAD / CAM / CAE systems:

PDM (Product Data Management) - module allows to manage product data throughout the life cycle of products in the design and pre-production.

TDM (Technical Data Management) - database management module data including document design and technological documentation.

CAD (Computer-Aided Design) - module of computer geometric modeling (design), which encompasses the creation of geometric 3D models of products, and the generation of drawings with support of product;

CAM (Computer-Aided Manufacturing) - module of technological preparation of the production;

CAE (Computer-Aided Engineering) - module of engineering computer analysis.

The main direction of development of modern CAD - is to enhance their intellectual functions, to develop parallel design and engineering. In the simplest case, the system only remembered "history" or a sequence of steps performed by the designer. Objects form the "integrity", including multiple serial representations of the same "essence". For example, the element may be of interest to the designer to position the aesthetic shape and to the engineer in terms of computational complexity of the surface in terms of techniques applicable stamping process for its manufacture. The object allows you to combine these representations that can effectively implement ideas with Ñ- technology.

C-technology (design and technology design) - is essentially new, integrated approach to the design. It is based on the idea of a combined product design, as well as processes for manufacturing and support coordinated by a specially created for this purpose distributed information environment.

Thus, integrated CAD modules cover the entire spectrum of industrial applications. We believe that in contemporary technical universities, all students must gradually learn all of the above modules during training.

Because our department mainly works with students of first and second courses, we see our mission in the CAD module of the training of this student contingent.

First-year students in the first semester are invited to explore two- and three-dimensional computer-aided design and drafting Autodesk AutoCAD system. Then in the second semester and third semester sophomore year our students study SolidWorks and Autodesk Inventor CAD-systems.

The arguments in favor of choosing SolidWorks and Autodesk Inventor CAD-systems were compatible drawings generated by them and the availability of these systems for the students, in addition to both systems based on the technology of three-dimensional parametric modeling.

The advantages of Solid works systems for us are the following:

1. A standard user-friendly Windows GUI.
2. Quite a long time used in many design offices.
3. Very comfortable creating a three-dimensional sketch.
4. Interaction with Excel, Word and other Windows applications.

Advantages of Autodesk Inventor system for us are the following:

1. Fully compatible with the DWG format.
2. A complete library of standard elements.
3. Possibility of using two-dimensional parametric elements of AutoCAD to create of the new 3D models.
4. Possibility of constructing various elements of a basic sketch.
5. Autodesk develops its own core program, so it is expected more progress in the development of new versions of software.
6. Applied technology of adaptive modeling, with changing the size of a single element-we can change the size of other conjugate elements of the model. This allows you to concentrate on the functionality of the assembly, and not on the size of its constituent parts.

It should be noted that the scientists of the department of descriptive geometry and graphics of the St. Petersburg Mining University, is currently have been working on the development and improvement of the application of CAD, with the involvement of students in these activities. For example, student R. Glukhov and scientist A. Folomkin (2016a; 2016b) developed an application AutoCAD library. It can be used by students in the performance of drawings and graphic works in the framework of practical training, course and diploma projects, as well as a good and simple example of the use of software to adapt to computer-aided design systems. The authors also have developed an application based on AutoCad API using Visual Basic for application; it allows you to automatically place the necessary text information in the template design document. Moreover, our scientists have been working to improve the use and further implementation of parametric dependencies implied in the course “Engineering and Computer Graphics” (Voronina, Moroz & Tretyakova, 2016). Scientists from other universities in Russia have been working actively to solve complex problems of descriptive geometry by means graphics systems also. For instance, student K.A. Vuklov (2014) under the leadership of the scientist N.E. Suflyaeva and V.A. Dudoladov (2015) from Bauman Moscow State Technical University has presented a work, comprising the tasks of descriptive geometry using Auto CAD environment and a program to automate a set of projecting lines on the main plane of the projection by the built environment in programming of AutoLISP. This is possible thanks to the fact that the ACAD editing and AutoLISP language interpreter is a single system: any AutoLISP function can be called from the graphical editor, the editor and any command can be used in the program in AutoLISP. AutoLISP application possibilities are very broad and diverse.

As a result of our research we came to the conclusion that the second principle, which should be the basis for subsequent foresight studies DG, EGCG departments should be the principle of student learning, which combines: training students to work in a variety of modern CAD systems (e.g. SolidWorks and Autodesk Inventor) with the mandatory involvement of students in research work in the above areas.

Impact of Industrial 4.0 ideology on the DG, EGCG

The most significant result in the development of CAD software is the creation of interactive graphical editors to work with two-dimensional and three-dimensional geometric objects or, in other words, the CADD. In general, most image editors still work the same way, creating geometric objects through the use and editing of geometric primitives. Currently, however, there was a whole series of highly specialized tools. Until recently, the development of CAD software moved towards solving the following problems: the software interface, the efficiency of solid modeling, parameterization and associativity. However, the current understanding of the design process proceeds from its genetic unity with the production process.

The practical implementation of the requirements of industrial production requires modernization of design and technology and production processes both within individual companies, as well as in terms of “extended enterprise”, uniting all suppliers, subcontractors and participants in the design and manufacture of products. Currently, the most radical means of addressing the problems of modernization is the introduction of integrated information technologies based on the use of modern computer technology and network solutions. Among the most effective technologies providing a significant gain in the short term are computer-aided design, engineering analysis and technological training (Systems CAD / CAM / CAE), as well as production information management system (the PDM system) (Chumakov & Stasevich, 2012).

About four years ago in Germany it was predicted and initiated fourth industrial revolution (the Industrial Revolution) under the abbreviation Industrial 4.0. In the near future it will radically change our workplace and make all the facilities we have created work for us. Currently, Industrial 4.0 - is the current trend of automation and communication technologies in the production of cyber-physical systems to the cloud.

Why is the idea of developing a single common platform for the fourth industrial revolution?

The main activity of the machine-building enterprise is the development and production of innovative product - high-tech product: the device or devices. The idea of flexible manufacturing is becoming very popular. Of particular importance is the flexibility of the production processes for small and medium-sized enterprises, as a key benefit, improving the competitiveness of firms. Flexibility reduces the output time to market the product. This requires a reduction in the duration at each stage of the development of manufacturing processes, reducing the total cycle timing works. Agile enterprise must be quickly readjusted production processes under a different kind of execution or other type of product. A technology that provides such flexibility is the automation of production processes on the basis of information systems (Dudkin, 2010).

In modern conditions the company faces the task of expanding the range and improving the quality of products, prompt response to requests from its customers, reduce production costs and improve economic efficiency. Particular attention is paid to the competitiveness of the products, which is laid at the design stage of the product. From how this operation is carried out, ultimately, depends on how the final product will be perfect (Potemkin, Lagutova & Kuznetsov, 2006).

Solution of the above problems has become so urgent, that raised the question of standardization of systems CAD / CAM / CAE and information technology in general. Daimler-Benz Group made a proposal called "Initiative of advanced information technology", which was supported by British Aerospace, FIAT, Renault, SAAB, Volkswagen and many other companies.

Another project called CAD 2000 combined company Audi, BMW, Mercedes-Benz, Porsche, Volkswagen. These projects try to solve the enormous scale and complexity of the search problem standard solutions that can satisfy a myriad of application requirements from design to manufacturing, as well as information and data management libraries of standard components.

German industry year until 2020 want to invest € 40 billion in commercial Internet infrastructure. European investments in the fourth industrial revolution amounted to EUR 140 billion per year. Of the 278 companies surveyed in Germany, 131 said that already "involved in Industrial 4.0».

In this regard, including urgent developing of an integrated system of organization of educational process need is acquired; it is a necessary stage of technical modernization of the university system and its inclusion into the ideology of Industry 4.0.

Upgrading technical university educational system involves the implementation of a number of interrelated steps: analysis of the federal state educational standards, Logistics University, the educational process, organization and implementation of innovative technology, etc. (Silnova & Karamzin, 2012).

As a result of the ongoing fourth industrial revolution, modern engineering students must be prepared to meet the needs of Society 4.0 and Industrial 4.0 (Richert et al., 2015). Industry 4.0 is characterized by individualized and crosslinked production process on the basis of the technological concept of cyber-physical systems and Internet of things at the same time.

Scientist M.I. Abashin from Bauman Moscow State Technical University and other researchers point to the fact that the whole course of bachelors' study in the first four semesters in various technical universities is similar (Abashin et al., 2014).

Therefore, we believe it is possible and necessary to consider the third principle of subsequent foresight research of development of departments of DG, EGCG - to integrate the efforts of departments of DG, EGCG in order to conduct Foresight study of graphics departments.

In addition, we believe that in this context, is growing rapidly the education market in this area, we need to explore the potential of new opportunities and the learning environment. So we consider the fourth principle of subsequent foresight research of development of departments of DG, EGCG is possible. It is necessary to take into account the potential opportunities of development of education market and training lecturers.

DISCUSSIONS

A sufficiently large number of researchers now are in the process of finding ways and means of improving the geometric - graphic preparation (Surynkova, 2014; Gornov, Usanova & Shatsillo, 2014; Heifetz, 2016; Zavalishin, Astashov & Oshkina, 2015; Guznenkov & Yakunin, 2016; Borovikov & Ivanov, 2015; Dudoladov & Suflyaeva, 2015; Blinov, 2013).

M.V. Voronina (Voronina *et al.*, 2016) from Saint-Petersburg Mining University discussed in their researches about the use of modern technologies in the teaching discipline "Engineering graphics" (Tretyakova et al., 2016; Folomkin *et al.,* 2016). M.V. Voronina and Z.O. Tretyakova (2015), O.N. Moroz *et al.* (2016) discussed also about the features arising from the teaching of this discipline for foreign students.

The objectives of our study coincide in many respects with the aims of research scientists such as Petra Surynkova from Faculty of Mathematics and Physics, Charles University in Prague. Our common objectives are: to stimulate students' interest in the study of DG, EGCG, motivate them, improve their understanding of geometry, innovate the methods of teaching geometry, achieve better results in examinations and put emphasis on practical use of geometry. We also would like to attract students to the traditional topics of DG by using modern methods. And we totally agree that we should not suppress students' independent thinking.

But we came to the conclusion that we don't completely agree with Aleksandr Heifets from South Ural State Research University (2016), who offers to state each section DG only from the point of 3D-modeling. Of course, graphic science must be constantly reviewed and developed, taking into account the trend of global development, which is of the explosive development of technology and the transition to a new integrated technological system. Nevertheless, we do not agree with scientist A. Heifetz that today DG as an academic discipline is a deterrent to the development of modern trends of geometric modeling. We can't agree with this, because in the first place we believe that DG develops students' spatial thinking and in the future - their ability to design and model.

CONCLUSION

The need for foresight DG Research departments, EGCG is completely obvious. Principles that in our opinion should be considered into large-scale Foresight researches of development strategy of DG, EGCG.

1. The principle, which combines immediately with the first semester the strategy of the mandatory training students by both ways in the same time: training students classical methods of solving problems of DG and training students to work in a modern CAD system.
2. The principle, which combines: training students to work in a variety of modern CAD systems and the mandatory involvement of students in research work in the above areas.
3. The third principle is to integrate the efforts of departments of DG, EGCG in order to conduct Foresight study of graphics departments.
4. The fourth principle is to take into account the potential opportunities of development of education market and training lecturers.

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

1. Leading industrialized nations are actively promoting, in parallel with its own Industrial 4.0 platform.

U.S. Industrial 4.0 is called Industrial Internet Consortium. This consortium was founded in March 2014 the company AT and T, Cisco, General Electric, IBM and Intel jointly. This nonprofit-profit organization that rose to the top in 2016 to 200 members. The participants also included and American organizations and individuals.

In Japan Industrial 4.0 exists under the name "Industrial Value Chain Initiative (IVI). The initiator of the creation of a Japanese corporate business. China also strongly supported the planned transformation into a global industrial power, “Made in China 2025”. In addition, South Korea is already an investor in the so-called smart «Smart» plants. In several European countries, there are comparable with Industrial 4.0 platform. For example in France this is the “Industrie Futur”.

All this will create the preconditions of our country, which has definitely tremendous potential, not just non-slowly join in “The fourth industrial revolution”, but also to actively implement their own platform, parallel Industrial 4.0, and it is with obligatory participation of leading technical universities, including training of qualified specialists required for this breakthrough. What, moreover, will allow Russia to totally implement the best development including Industrial 4.0 platform governmental system of production and education.

2. New Internet - technology should be developed in close connection with the higher education system, not limited to the industrial sector. If the implementation of integrated information technology comes originally not on the basis of the leading technical universities, it must necessarily have an immediate response in the curricula and working programs of all Russian technical universities.

We’d like to join forces efforts towards changes in DG, EGCG, because design activity with the introduction of CAD / CAE / CAM-systems change, high-tech manufacturing advancing by leaps and bounds.

The technical universities organization, content, technology DG, EGCG should change appropriately and ahead, using the most modern information and communication technologies engineering.

Problems of intensification of DG, EGCG in universities should be more friendly to solve all problems of our community of graphic disciplines lecturers.

References

Abashin, M.I., Vinokurova, E.V., Galinovskiy, A.L. & Korshunov, S.V. (2014). ‘World tendenñies of engineers training system improvement’. *Bulletin of Moscow State Open University. «Pedagogy», 2:* 57-65.

Balyakin, V.B., Ermakov, A.I. & Chempinsky, L.A. (2011). ‘Training for innovating engineering through parametrization’. *Bulletin of Samara state aerospace university named after academician S. P. Korolyov (National Research University), 3:* 315-322.

Blinov, A.V., Bozhko, U.V., Korobov, V.M. & Shcherbakov, V.V. (2013). ‘Using CAD-systems and information technologies in the course “Descriptive Geometry and Engineering Graphics’. *Modern problems of science and education, 2:* 1-8.

Borovikov, I.F. & Ivanov, G.S. (2015). ‘Geometric transformations in engineering geometry’. *Science and Education, 5:* 334-347.

Borovkov, A.I. (2012). *Modern Engineering Education*. St.Petersburg: Publishing house of the Polytechnic.

Chumakov, O.A. & Stasevich, N.A. (2012). *Fundamentals of computer-aided design: a teaching aid*. Minsk: BSUIR.

Dudkin, D.V. (2010). 'Overview of automation methods of small and medium engineering enterprises based on CALs -technologies and systems engineering approach'. *Bulletin of Don state technical university, 10(7):* 1094-1101.

Dudoladov, V.A. & Suflyaeva, N.E. (2015). 'Methods of geometric-graphic preparation of specialists at the faculty "Information and Management System" MSTU'. *Engineering Bulletin Bauman Moscow State Technical University,* 7: 1001-1012.

Folomkin, A.I., Voronina, M.V., Moroz, O.N. & Tretyakova, Z.O. (2016). 'Development of training mining and graphic libraries for CAD KOMPAS'. *Proceedings of the X St. Petersburg Congress "Professional education, science and innovation in the XXI century" Saint-Petersburg, Russia, 2:* 326-329.

Glukhov, R.A. & Folomkin, A.I. (2016a). 'Development of software libraries weld symbols for Autodesk AutoCAD'. "The scientific community of students. Interdisciplinary Research". *XI student of the international scientific-practical conference, 8(11):* 81-84.

Glukhov, R.A. & Folomkin, A.I. (2016b). 'Software AutocCAD of adaptation on the example of automating the creation of the sheet'. *Proceedings of the III International scientific and methodological conference "Modern educational technology in the teaching of natural sciences and the humanities".* Saint-Petersburg Mining University, 660-663

Gornov, A.O., Usanova, E.V. & Shatsillo, L.A. (2014). 'Basic geometric-graphic preparation on based on 3D-electronic models'. *Geometry and Graphics, 2(3):* 43-49.

Guznenkov, V.N. & Yakunin, V.I. (2016). 'Computer graphics – basics geometric-graphic preparation'. *International Research Journal, 4(46):* 31-33.

Heifetz, A.L. (2016). 'Descriptive geometry as a factor limiting the development of geometric modeling'. *Problems of quality graphic preparation of students in a technical college: tradition and innovation, 1:* 298-325.

Ivaschenko, V.I. (2009). 'The engineer-graphic training based on CAD/CAM program'. *High education in Russia, 5:* 166-168.

Kakhkharov, A.A. (2015). 'Features of teaching descriptive geometry and engineering graphics with the use of modern computer technology'. *Nauka-rastudent: 6(18):*14-19.

Kospentaris, G. & Panagiotis, S.P. (2010). 'The Effects of High School Geometry Instruction on the Performance in Spatial Tasks'. *Journal for Geometry and Graphics, 14(2):* 227-244.

Moroz, O.N., Voronina, M.V., Tretyakova, Z.O. & Folomkin, A.I. (2016). 'The use of modern information technologies in the discipline "Engineering and Computer Graphics"'. *Proceedings of the X St. Petersburg Congress "Professional education, science and innovation in the XXI century" Saint-Petersburg, 2*: 34-38.

Nesterenko, L.A. (2004). 'Modern information technologies in the educational process of the department of engineering and computer graphics'. *Modern information technology, 2:* 262-265.

Potemkin, A.N., Lagutova, A.V. & Kuznetsov, S.G. (2006). 'Using modern computer technologies in teaching students engineering specialties'. *Modern information technology, 4*: 86-88.

Richert, A., Plumanns, L., Gross, K., Schuster, K. & Jeschke, S. (2015). 'Learning 4.0: virtual immersive engineering education. Digital universities'. *International Best Practices and Applications, 2(2):* 51-66.

Silnova, S.V. & Karamzin, A.G. (2012). 'Development of an integrated organization of the educational process as a stage of modernization of the educational system of high school'. *Problems and prospects of development of education in Russia, 17:* 177-183.

Stachel, H.D. (1994). 'The Art of Grasping Spatial Relationships'. *Proceeding of the 6th ICECGDG.* Tokyo, 533-525.

Stavric, M., Wiltsche, A. & Schimek, H. (2005). 'New dimension in geometrical education'. *Scientific and professional journal of croatian society for constructive geometry and computer graphics, 9:* 45-53.

Suhomlin, V.A. (2008). 'Virtual National University IT-education: from the con-conceptions to implementation'. *Applied Informatics, 3(15):* 89-115.

Surynkova, P. (2014). Modern descriptive geometry supported by 3D computer modelling. *International Conference on Mathematics Textbook Research and Development 2014 (ICMT-2014).* Southampton: University of Southampton.

Tretyakova, Z.O., Voronina, M.V., Moroz, O.N. & Folomkin, A.I. (2016). 'Computer graphics - an important aspect of the training of engineers'. *Proceedings of the X St. Petersburg Congress "Professional education, science and innovation in the XXI century" Saint-Petersburg, Russia, 2:* 257-262.

Volkhin, K.A. & Astakhova, T.A. (2012). 'Use of information technologies in the course of descriptive geometry'. *Omsk Scientific Bulletin, 2:* 282-286.

Voronina, M.V., Moroz, O.N., Tretyakova, Z.O., Folomkin, A.I. (2016). 'Descriptive geometry in educational process of Technical University in Russia today'. *International journal of environmental & science education, 11(17):* 10911-10922.

Voronina, M.V., Moroz, O.N. & Tretyakova, Z.O. (2016). 'The use of parametric dependencies implied in the course "Computer Graphics"'. *Proceedings of the III International scientific and methodological conference "Modern educational technology in the teaching of natural sciences and the humanities".* Saint-Petersburg, Saint-Petersburg Mining University, 259-264.

Voronina, M.V. & Tretyakova, Z.O. (2015). 'Training foreign students learning the subject "Descriptive geometry, engi-neering and computer graphics" in the Technical Russian University in Russian language as foreign language: problems and solutions'. *Proceedings of the V International scientific and methodological conference "Actual problems of the humanitarian knowledge in higher technical educational institution".* Saint-Petersburg, Russia: Saint-Petersburg Mining Universit, 273-276.

Vukolov, K.A. (2014). 'The solution of complex problems on descriptive geometry by AutoCAD graphics system resources'. *Youth Science and Technology Bulletin Bauman Moscow State Technical University, 10(1):*11-17.

Zavalishin, E.V., Astashov, A.M. & Oshkina, L.M. (2015). 'Teaching Computer Graphics to Students Majoring in Civil Engineering'. *Integration of education, 19(2):* 67-72.