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Descriptive geometry in educational process of Technical University in Russia today

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ABSTRACT

The relevance of the investigated problem is caused by the need for monitoring the impact of the Unified State Examination (USE) on the level of mathematical culture and the level of geometric literacy of applicants and students of modern engineering universities of Russia. The need to determine the position of Descriptive Geometry in the structure of modern higher engineering education. The aim of the article is to study the USE impact on the overall level of training, including the level of geometric literacy of applicants and students of technical universities in Russia. The identification of the specific features of the modern structure of higher engineering education in Russia. The determination of the position of Descriptive Geometry in this structure. The leading approach to the study, which is in the solution of this problem, is to monitor the current USE system, and to monitor the structure of modern higher engineering education in Russia. This is an integrated approach, which allows to address this issue as a process of purposeful national formation of the best overall level of mathematical culture to students of technical universities in Russia. The article presents the results of monitoring of the USE impact on the overall level of training, including the level of geometric literacy of applicants of technical universities in Russia. The results of monitoring of the specifics of the existing structure of modern higher engineering education in Russia. The place of Descriptive Geometry in it. The structure of training of students of Descriptive Geometry at the St. Petersburg Mining University. Article Submissions are of practical value to teachers of technical universities, their adaptation to modern conditions of professional work in higher engineering education.

KEYWORDS
Unified State Examination (USE), the structure of higher engineering education, teaching and methodical complex (TMC), descriptive geometry (DG), the state-funded places, the applicants, the level of geometric literacy

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Introduction

First of all, let us tell you, dear readers, that this article is published in order to acquaint the international association of mathematics and geometry, as

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well as all those involved in education, with the features of the structure of modern higher engineering education in Russia, with a contingent of entrants as well as with the implementation of the discipline DG to the structure of the educational program.

In future, series of publications related to higher technical education in the field of DG, engineering and computer graphics are to be published.

It is known that according to the Law of the Russian Federation "On Education" (1992) and with Russia joining the rank of participants of the Bologna process in 2003, nowadays in Russia, a one-tier system of high school (specialist) was replaced by a two-tier system (Bachelor/Master) of higher education. The introduction of two-tier system does not entail the obligation to reject non-specialty programs.

In connection with the requirements of the state in 2016 the largest number of state-funded places allocated to the following areas of training: "Computer Science and Engineering" - 26000 places, "Agriculture, forestry and fishing" - 22000 places, "Equipment and Land Transport Technology" - 20000 places, "Equipment and construction technology" - 15000 places, "Mechanical Engineering" - 14700 places (the Russian Federal education portal, 2016).

In Russia, there are approximately 200 engineering Universities with an enrollment of more than million people. Every year more than 200 000 people accepted into the first course of the technical universities of Russia are on the free of charge places, paid by the state. In addition, training is carried out on a paid (contract) basis. And every year different companies pay for the growing number of students.

Today Russia has one of the highest levels of employment and wages for those who have completed engineering direction.

Admission to engineering universities, as well as to other universities in Russia, depends on the results of the exam. Materials All-Russia Opinion Research Center found that the attitude towards the USE is formed by a number of criteria related to its objectivity. Among the others, they also lay emphasis on the following criteria: assessment of the outcomes of the educational activity, the procedure of the exam, the presence of psychological disorders and the need to prepare students to pass this exam (Berzin, Berzin & Maltsev, 2016). Existing studies generally showed that the population of Russia as a whole appreciates the exam, including the latest innovations associated with it.

Factors affecting the choice of university for the degree of selectivity were marked on the basis of monitoring data and the Economics of Education Rating reception (Prahov, 2015). It is shown that the choice of an applicant by selective high school is determined not only by received exam scores. But by the characteristics that are not directly related to the ability of the entrant: the level of parental education, family financial situation, the size of its cultural capital, as well as the characteristics of the school (school type and the presence of a particular specialization in the class), the size of financial investments in additional training for admission. Confirmed influence of these factors casts doubt on the equal opportunities for admission to universities and access to quality higher education for students from families with low socioeconomic status.

There is an analysis that allows to see students' dynamics of mastering course content elements of general physics and mathematical analysis of the first semester, to investigate the influence of the previous material, exam results on successful assimilation of subsequent topics (Zaitseva et al., 2011). There is the dynamics of evaluation of mastering level courses of general physics and mathematical analysis of applicants (for exam results), first-year students of the Physics Department at the entrance to the educational process, in the middle of a semester and at an examination. These results allow us to determine the connection between the performance at the examination and mastering the content of general physics and mathematics.

Besides, we can observe the model of the analytical competency of higher school students, while teaching special mathematical disciplines with the help of information and communications environment through the integration of mathematical, information and pedagogical knowledge (Valeeva, Bushmeleva 2016; Khairullina et al., 2015). This study introduces conditions for effective formation of students' analytical competency, which provides them with the opportunity to work and continue their vocational training.

The mechanisms of perception of the current information system of higher education and the construction of scenarios of development depend on user-defined (Levina et al., 2016). This approach allows making adequate managerial decisions in conditions of high uncertainty and possible opposite requirements of educational agents.

Some scientists have attempted to develop main themes have derived from the problematic of the emergence of regional and national models of education (Saprykin, 2005; Dale, 2005; Dale 2009).

Scientist A.L. Heifetz (2016) gives a brief historical overview of the problem of irrelevance of DG as a discipline of graphics departments is considered as well as necessity of its replacement with a modern theoretical course. He shows existing opinions on the maintenance or the course of reorganization, analyze the arguments for and against and propose alternative drive concepts of the course.

Thereby there is no scientists' consensus about USE and about the place of DG in higher engineering education, so we need to explore it.

Materials and methods

Research methods

During the study following methods were used:

- Theoretical (analysis, synthesis, concretization, generalization);

- Diagnostic (questionnaires, interviews and testing);

- Empirical (the study of the regulatory and educational-methodical documentation of technical

universities of Russia, pedagogical supervision);

- Experimental (notes forming, controlling).

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, 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 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 results of monitoring of the impact of the exam on the level of preparation of students of technical universities of Russia

The conclusions made by us after the monitoring of the USE in 2016, as well as research into training levels of the general mathematical culture of applicants and first-year students of the St. Petersburg Mining University showed:

1. Unified State Examination was conducted effectively and impartially in 2016.

In this year the exams were really effective and fully impartial. The exams were conducted in all 85 regions of Russia, as well as in 52 countries of the near and far abroad. About 750 thousand members passed the exams. It involved about 5.7 thousand points of the examinations, more than three thousand federal public and online observers and thousands of regional observers. Graduates had absolutely no way to use cheat sheets on the exams or to learn test content in advance. Parents and teachers did not have any chance to intervene in the process of examination and summarizing the results.

2. Special examination in math, containing geometry was sufficiently complex.

A new two-tier model of math exam is compulsory for all graduates and plays the role.

Graduates who do not plan to enter the technical universities, took exam in basic math, it was not a complicated level. Graduates planning to enter the technical Universities took a special exam, which included geometry. And it was complicated with the maximum degree of sophistication.

A possibility to guess the right answer is completely excluded; almost all tasks require decision process. Geometry tasks are obligatory – they are four tasks in part B (two for plane geometry and two for solid geometry), the task C2 (target 16), and for some students there is an unattainable task C4 (target 18). To get a high score on the specialized mathematics, graduates knowledge of geometry should be on top.

3. In 2016 there were 2 compulsory examinations: mathematics and Russian language.

The Russian language exam revealed the level of knowledge of Russian language and literature of applicants of technical universities.

The State sets a minimum score. Those graduates, who have bad knowledge and got a lower score, are not allowed entering technical universities.

The third exam for admission to technical universities was a graduate exam of choice: physics, computer science or chemistry.

Some graduates simply do not overcome the minimum threshold of points established by the state in a result of raising the level of training students of technical universities. Quite a number of graduates have not passed the math for a profile Technical University. And they are not even able to enter for a fee. Repeating the examination of choice was forbidden.

17% of graduates in Russia this year has not passed the math as profiled.

At the same time, talented graduates from across the country, regardless of family income, were able to enroll in prestigious technical universities of Russia in the state-funded places of their choice.

More than 70% of graduates enrolled in the leading universities of Moscow and St. Petersburg in 2016 - from the remote regions of Russia.

4. Availability of the military department of the university has an impact on the University competition.

In Russia, studying at some technical universities young men have an opportunity to be trained in the military departments in these universities at the same time. And, at the end of the training, along with a diploma of higher education, they get a rank of the officer or sergeant reserve. That naturally raises the interest of students who are fit for military service and increase competition in these universities. In St. Petersburg, for example, there are 14 major technical universities, and there are 6 which have military departments or centers, including the St. Petersburg Mining University. Naturally, competition in these universities not only in the budget places, but also in the fee places is high.

5. In addition to high-level academic training of students of technical universities, first-year students who have successfully passed the exam selection, already know how to cope with serious stressful situations, with certain difficulties and are easier to adapt to the university.

6. Education program of training specialists remains popular in Russia with both applicants and employers.

The results of monitoring the specifics of the existing structure of modern higher engineering education in Russia

Three levels of higher engineering education in Russia

Currently, there are three levels of higher education in Russia:

1. Basic higher education in a bachelor degree lasts 4 years, it leads to the award of the degree of "Bachelor of Engineering and Technology" on any field of study, for example, "Computer Science and Engineering". This is the first degree of higher technical engineering education at the university. That is equivalent to B.Sc. extent in Western Europe or the United States.

2. The degree of "Master of engineering and technology" in any field of study is obtained after the degree of "Bachelor of engineering and technology." And you can chose the direction of training, different from the bachelor degree program obtained. Education in the master's degree lasts 2 years. This degree is equivalent to the degree of M.Sc.

3. The qualification of "Engineer" for any speciality. For example, the qualification of "Engineer" speciality "Industrial and Civil Engineering" can be awarded. Training on speciality lasts 5 years. Qualification "Engineer" is still more prestigious in Russia, than the degree of "Bachelor".

Two levels of academic degrees of engineering education in Russia

After receiving the degree "Master" or the qualification "Engineer", you can continue to study for academic degrees.

1. The candidate of Technical Sciences, learning takes place in post-graduate training period of 3 years, equivalent to Ph.D.

2. Doctor of Technical Sciences, the highest level of training, can be obtained after a scientific degree of candidate of Technical Sciences, learning takes place in the doctoral training period and lasts 2 years, it is equivalent to Professor.

Defense of theses happens publicly. Bachelors are not allowed to go to postgraduate school, and certainly not to doctoral studies. Rarely, but it happens that for applicant's special services and openings, a graduate student is awarded a degree of Doctor of Technical Sciences without the awarding of the candidate of Technical Sciences degree.

Two levels of academic status of engineering education in Russia

A candidate of Technical Sciences, who reached success in a particular profession, receives academic title «Docent», as a rule.

A Doctor of Technical Sciences, who was granted special recognition in any activity, receives academic title «Professor», as a rule.

It is rare, but a person, who is held in greatest respect in the professional environment, but does not have a scientific degree at all, can be assigned to academic rank of Professor.

The availability of teachers' scientific degrees and ranks also depends on the prestige of the university in Russia. In the most prestigious universities, such as the St. Petersburg Mining University teacher has the right to teach students if he has at least a candidate of Technical Sciences.

Place of descriptive geometry in the structure of engineering education today

Currently, it turned out that, despite the large number of universities and departments of descriptive geometry and graphics in them, many descriptive geometry students at the same time in different cities of Russia, there is not an actively working geometers community in Russia unified for all regions. Nor is there a single TMC. Despite the fact that academic departments actively participates in conferences, hold contests, most of them work separately and have their own TMC. This certainly has some advantages, each Department is proud of the history of its development, of its founders. The direction of

development of each of the department is often narrowly focused on particular areas of training of a particular university.

After monitoring the curriculum of descriptive geometry and graphics training in various technical universities, we can note that the approaches to teaching students graphics are very similar in Russia and in other countries, such as Japan, which can be seen in the works of K. Kondo, K. Mende & K. Suzuki (2005). They with the Japan Society for Graphics Science undertook a survey on the education of Graphic Science and related subjects at Japanese universities in the 2002. These approaches depend on what experts they train. You can also pay attention to particularities of different university approaches to the formation of university curricula.

In the course of our research, we identified four types of technical universities of Russia, depending on what students they prepare.

1. A number of universities that train specialists mainly in the engineering fields equally focus on traditional Descriptive Geometry at the beginning of training, and on engineering and computer graphics in the end.

This type of curriculum includes the teaching of DG in the first term starting September 1st, lasting 18 weeks. The number of academic hours of educational discipline "Descriptive Geometry": Lectures - 18 hours (every 2 weeks), or 36 hours, practical classes - 36 hours. Students take the exam in January.

Practical methods for creating graphics and doing engineering tasks are taught in the second semester. Academic discipline "Engineering and computer graphics" is usually taught in the second term, starting in February, lasting 18 weeks. Average: Lectures - 18 hours (and sometimes no lectures at all), practical classes - 36 or 51 hours. Students do a pass/fail test (quiz) at the end of May or early June.

2. Universities, specializing in the field of architecture, construction and art are focused on traditional DG, on its particular direction, which is necessary for them, as well as on the development of geometric spatial thinking. That is, Geometry of Space is taught through DG.

3. The third type of universities specializes in training specialists in IT sphere, seeks to introduce new computer technologies for the graphic presentation, combines computer graphics programming with using commercial CAD systems. In the universities of this type, learning of DG takes place in the course of engineering and computer graphics for only one, and usually the second term. During further educational activities, all students develop and apply their knowledge in the field of geometry and graphics.

4. Russian largest technical universities, which train specialists in various fields of engineering sciences, have various curriculum and working training programs, which depend on the direction of students' training. All the three types mentioned above are often combined in order to improve the quality of education.

There are also "Descriptive geometry, engineering and computer graphics" courseworks, performed by the students themselves in the second year under the supervision of descriptive geometry and graphics department teachers, such as is done in the St. Petersburg Mining University.

The graphic preparation of students at the St. Petersburg Mining University

St. Petersburg Mining University in 2016 accepted 1,500 people to the state-funded places.

Beyond that, a large number of students, including non-citizens entered the Masters (about 200 people), post-graduate studies, preparatory department for foreign citizens (about 150 people), Faculty of secondary vocational education (college of Geodesy and Cartography - about 400 people).

Students can also be accepted on a paid (contract) basis. Students' admission is carried out only for training on a full-time basis (except college), that certainly improves the efficiency and quality of the higher technical education.

In our department of "Descriptive Geometry and Graphics", the training of all the above-mentioned groups of students is realized. The process traditionally begins with a study of DG, engineering and computer graphics, and finishes with a course work (Tretyakova, 2012; Tretyakova, 2015; Moroz, Folomkin & Tretyakova, 2016; Tretyakova & Voronina, 2016; Voronina, Moroz & Tretyakova, 2016).

All students, who study "Descriptive geometry, engineering and computer graphics," are divided into groups of not more than 15 people in each. It certainly improves the quality and efficiency of the educational process.

As a rule, future bachelors and specialists study descriptive geometry in the first term, the average is 18 hours of lectures and 36 hours of practical classes, the term ends in January with the exam in the form of testing. In the second term, students study engineering and computer graphics, on average they have 54 hours of classes, a form of control is often a differentiated the pass/fail test (quiz). In the third semester, students complete their course work, the topic of which corresponds to the direction of training.

The students of the preparatory department for foreign citizens learn the basics of descriptive geometry, engineering and computer graphics in the second term, as the first term they learn Russian language (Voronina & Tretyakova, 2015; Moroz, Voronina & Tretyakova, 2016).

The difference between job training programs is in the volume of the material studied, and in the complexity of the objects modeled.

Discussions

We join Petra Surinkovoy's opinion (2014) from the Czech Republic, that descriptive geometry and drawing are very unpopular subjects in secondary education because of their complexity. It was noticed, that the interest for these disciplines tends to decrease in recent years in schools, including Russia. Recently, some schools are fixated on preparing for the exam only.

We're sure, just as Petra Surinkova, there is the need to teach students high quality spatial geometric formation starting from elementary school, because the development of spatial imagination in early childhood is crucial in the future. Now, learning the basics of descriptive geometry is included in academic subject program "Drawing" in some Russian schools. Unfortunately, most schools do not have this subject at all.

Of course, we have to follow the general trends and adapt teaching methods to the real practice, using up-to-date software. However, it does not mean that the classic image is outdated and it does not cancel such school subjects as "Fine Arts" and "Drawing". All learning tools will be useful for students in the development of initial ideas and in finding geometric solutions of the problems and in the further study of engineering disciplines direction. Painting and drawing help students develop their design skills, object-modeling skills.

It should be noted that, regardless the presence or absence of "Drawing" in a school, in all Russian technical universities, students learn at least basic geometric and graphic disciplines during the initial courses. These disciplines include descriptive geometry, engineering and computer graphics. So every year all over Russia, 200 000 first-year students study descriptive geometry, engineering and computer graphics. These are huge numbers, and, of course, further research on this industry is needed. Currently, discussions are conducted in Russia on this subject, but they are separated and formed in narrow circles. As contrasted with the discussions held by international communities of mathematicians and geometers.

Studying these discussions, 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.L. Heifetz (2016) 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.

In the second place, because of the fact that our country has three century-long history of Russian engineering education in its crucial points (Saprykin, 2012a). In this connection the concept and structural parameters of Russian system of engineering education have its own traditions, different from German, French, English and American models.

In the third place we have the special origin of "physic-technical" model of education in Russia. Of course, there are many similarities. In this context, we totally agree with the conclusions of the Russian scientist D.L. Saprykin (2012b) He shows detailed quantitative assessment of key indicators of development of system of engineering education of Russia in comparison with data from USA, Germany, France, England, Italy and Sweden 1800-1930. Moreover, in his investigations D.L. Saprykin (2012b) analyzes the development of and differences between the traditional and Russian versions of the European system of education in the natural sciences and engineering during the 19th century (2013). It focuses on the emergence of the concept of physic-technical education in Germany and Russia at the turn of the 20th century, which influenced the training of engineers-physicists internationally and also led to the

founding of a characteristically Soviet "PhysTech" system. The paper discusses the notion of long-term cycles in the development of Russian science and technology and the key role of the intellectual breakthrough at the start of the 20th century.

In this regard, we are fully on the side of Professor Helmuth Stachel of the Institute of Geometry, TU Vienna (1994). We believe that only with the help of special additional types real spatial form can be detected and 3D-objects analyzed in detail. Such additional types are more often the key to the solution of 3D-applications. They make art of DG sublime. Students study what conditions may be complete, and in particular, how they can be identified from classical descriptive geometry.

We believe that it is necessary to maintain the existing structure of the course of descriptive geometry, refined over many years of development of this course, comprehensively covering applied problems of geometric modeling.

Conclusion

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

1. The results of the exam in 2016 revealed the most talented graduates of schools from all regions of Russia, regardless of the income of their families. Moreover, engineering universities saw the best prepared and the most motivated applicants this year.

2. Confidence was build that, thanks to the exam and the efforts of schools, high level of students of technical universities that we can see today will only increase in the future.

3. There is no specific systematic research into the problem of the USE impact on the level of mathematical culture and the level of geometrical preparation of students of technical universities.

4. There is no scientists' consensus about the place of DG in higher engineering education.

5. Scientific-theoretical and methodological recommendations on formation of professional competence of teachers of engineering universities are not developed enough; they need to work professionally with modern contingent of students.

In the course of the survey, new questions and problems to its decision appeared. The transition to a two-tier system of higher education in Russia, USE innovations, the active development of information technology, software, require further ongoing monitoring and improvement of the educational process.

Therefore, it is necessary:

1. Continue to monitor the effect of the exam of the previous and subsequent years on the level of mathematical culture, including geometrical preparation of students of technical universities.

2. Conduct a study of existing methods of formation of competence of teachers of descriptive geometry, engineering and computer graphics at higher engineering and technical universities to continue their improvement with regard to modern trends and the level of students.

3. Explore the need to develop a single, integrated in all Russian universities educational complex on descriptive geometry, engineering and

computer graphics, having conducted preliminary monitoring of the existing systems.

4. Integrate Research of scientists of engineering universities of Russia with research of scientists from around the world in the field of descriptive geometry, engineering and computer graphics, including the purpose of further development of descriptive geometry as an art and science, improving the overall system and the structure of higher engineering education.

The contents of this article can be useful for teachers, adapting to the new conditions of professional work in the field of higher engineering education. And also for the education of specialists focused on the development of monitoring the quality of education.

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No potential conflict of interest was reported by the authors.

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