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HISTORY AND MODERN INTERPRETATIONS OF DESCRIPTIVE GEOMETRY IN TODAY'S RUSSIAN ENGINEERING UNIVERSITY

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The relevance of research: Our article describes the history of the origin of the Descriptive Geometry science and explain where Descriptive Geometry is in the hierarchy of sciences now. The relevance of the investigated problem is caused by the need to determine the position of Descriptive Geometry in the structure of modern higher engineering education. The aim of the article is the identification of the specific features of the position of Descriptive Geometry in the modern structure of higher engineering education in Russia. The leading approach to the study, which is in the solution of this problem, is 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 and geometry culture of students of technical universities in Russia. The article presents the results of monitoring of the place of Descriptive Geometry in the structure of modern higher engineering education; the structure of training of students of Descriptive Geometry at the Saint Petersburg Mining University. The article is of practical value for the lecturers of technical universities, their adaptation to the modern conditions of professional activity in higher engineering education.

Keywords: Descriptive Geometry (DG); Graphic Science (GS); Computer Graphics (CG); Unified State Examination (USE); teaching and methodical complex (TMC).

INTRODUCTION

This article is published in order to acquaint all those involved in engineering 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 engineering education in the field of DG, engineering and computer graphics are to be published.

Descriptive geometry is a basic academic discipline of engineering education. According to the famous scientist Hellmuth Stachel from Institute of Geometry (TU Vienna), Descriptive Geometry is a method to study 3D geometry through 2D images thus offering insight into structure and metrical properties of spatial objects, processes and principles. In the hierarchy of sciences it is placed somewhere within or next to the field of Mathematics, but also near to Architecture, Mechanical Engineering, and Engineering Graphics (Stachel, 1994a).

This discipline is very important for future engineers in terms of developing their skills of imaging spatial geometric objects on the plane of the drawing. The

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purpose of our study is to determine the current state of affairs in teaching descriptive geometry in Russia and to explain that descriptive geometry is very useful as a subject for the development of an engineer, physician and specialists from other fields. Because Descriptive geometry ensures the development of intellectual abilities of students through a volumetric perception of space and therefore has an indisputable need for the training of all engineers, doctors and other specialists. Moreover, a drawing, called the "language of technic", is an international means of communication (Saprykin, 2012 a, b, 2013; Tchoshanov et al., 2017; Kalimullin & Utemov, 2017). Naturally, the training to master this "language" perfectly is an indispensable condition for the preparation of a bachelor, master or specialist in any engineering specialty.

On the other hand, the scientist A. L. Heifetz (2016) from South Ural State University (Russia) considers, that Descriptive Geometry is a restriction (the same bag) in involving students in modern methods of geometric modeling and design, as well as a limiting factor of developing of graphics departments (Heifetz, 2016). He also shows existing opinions on the maintenance or reorganization of the Descriptive Geometry course, analyzes the arguments for and against and proposes alternative drive concepts of the course.

According to scientist Kenjiro Suzuki (1997) from the University of Tokyo, Graphic Science (GS) covers a wider range of topics than just Descriptive Geometry (DG) and with the emergence of Computer Graphics (CG) Graphic Science now encompasses an even broader set of topics. Therefore, it was felt necessary to re-define Graphic Science and involve the GS community in discussions on what Graphic Science is (Suzuki, 1997; Ino, 1997).

Gary R. Bertoline from Purdue University et.al describes the concepts of Descriptive Geometry as applied to solving spatial problems (Bertoline et al., 2009). He with his colleagues proves, that the Descriptive Geometry is used to solve of many types of spatial problems. 2-D geometric basic geometric elements of points, lines, and planes, used extensively in traditional Descriptive Geometry applications can be combined with 3-D geometric primitives to solve design problems, utilizing 3-D CAD and solid modeling software. He illustrates the application of Descriptive Geometry concepts in the design of a chemical plant. For the plant to function safely, pipes must be placed to intersect correctly and to clear each other by a specified distance, and they must correctly intersect the walls of buildings.

According to scientist Dr. Wolf-Dieter Klix from Institute of Geometry, Karla Nestler, TU Drezden (Klix, 2001). Constructive geometry is the expansion of the representational geometry by analytical methods, including the possibilities for computer use for calculation and drawing. The principles, methods and functions of constructive geometry as prerequisite for the successful use of graphical software or CAD.

DG is unique in the way how it promotes spatial reasoning, which is so fundamental for each creative activity of engineers, and how it trains the ability to express spatial ideas graphically so that they become understandable for anybody else. Thereby there is no scientists' consensus about the place of DG in higher engineering education, so we need to explore it.

METHODS OF RESEARCH

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 AND DISCUSSION

From the history of development of the Descriptive Geometry

Great German artist, mathematician and theorist of painting Albrecht Durer (1471 - 1528) for the first time successfully solved the difficult task of depicting a spatial figure on a plane. Durer first proposed to draw on the plane a plan of a geometric

body having three dimensions, from which one can get a complete idea of the shape of the given body. That is, Durer is first scientist, who uses orthogonal projection of bodies, as well as who project spatial curves into three mutually perpendicular planes. This method later became one of the main methods of descriptive geometry. Durer's treatise - "The Guide to the Strengthening of Cities" (1527) is devoted to the theory of fortification and to the theory of orthogonal projection.

The ideas of Albrecht Durer, developed by the architects Francois Durand and Girard Dezarg (1591 - 1661), the mathematicians Pierre de Fermat, Blaise Pascal and René Descartes (1596 - 1650). In 1640 Dezarg published the foundations of architectural drawing and the theory of cutting stones. In 1637 Descartes in the "Geometry" developed a method of orthogonal coordinates, which served as the basis for analytical and descriptive geometry. In 1674 the mathematician Claude Francois Millet Deschal (1621 - 1678) published the "Course or the world of mathematics", one of whose chapters was devoted to some pictorial methods of imaging (Alexandrova, 2002).

The military engineer Fresier (1682 - 1773) perfectly understood what prospects orthogonal projection opens for performing technical works, but nevertheless failed to understand the way, as Durer did, of the geometric nature of the problem. In his work "Theory and practice of cutting stone and wood, or a guide to stereotomy" printed in Strasbourg in two volumes in 1738 – 1739, Frezier designs an object on two surfaces - horizontal and vertical, he draws the intersection line using auxiliary secant parallel planes.

All previous ideas were generalized and developed to the level of an integral mathematically exact scientific discipline by the French engineer and mathematician Gaspar Monge. The prehistory of the development of this science stemmed from the narrow practical needs of obtaining images. Gaspar Monge said - "drawing is the language of technic". He considered his descriptive geometry not as mathematics, but as a region of graphics for which mathematics served as an auxiliary tool. In the Normal School, established after the 9th Thermidor (1794), he introduced the course of descriptive geometry for the first time into the curriculum. Gaspar Monzh became one of the founders of the famous Polytechnic School (Ignatyev & Mozar, 2015).

In the seventeenth and eighteenth centuries, a large number of graphic images appear in Russia in the form of plans for buildings, plants, land and cities. Outstanding Russian mechanic-self-taught I.P. Kulibin (1735-1818) and I.I. Polzunov (1726-1766) carried out their drawings in a way that was scientifically justified in 1799 by the founder of the descriptive geometry of Gaspard Monge.

I.P. Kulibin in the original brilliantly executed project of a wooden one-span arch bridge across the Neva River (1773) for the first time used orthogonal projections, which made it possible to carry out competent technical calculations

of this complex structure. A huge contribution to the development of descriptive geometry as a science that justified the rules of parallel rectangular projection was made by Russian mechanics, inventors and architects. Drawings made by I.I. Polzunov, V.I. Bazhenov and M.F. Kazak was the base that allowed the domestic builders and mechanics to implement unique architectural and construction projects.

The course of Descriptive Geometry as a discipline was first included in the program of the Institute of the Corps of Engineers of Communications, created in 1809, at the suggestion of its first rector, one of the students Gaspar Monzh, AA. Betancourt. In 1816, K.I. Potier published the first textbook in Russia. Since 1818 Sevastyanov Ya.A. became the leading lecturer in Descriptive Geometry. Sevastyanov's work contributed significantly to the inclusion of this science in the curricula of the Engineering and Artillery Schools, the Petersburg and Moscow universities, the Mountain Cadet Corps, and the Technological Institute. At the Kazan University, the course of descriptive geometry in 1822 was read by the outstanding mathematician N.I. Lobachevsky. Further development of this area of geometry, as well as a clear division into theoretical and applied parts is associated with the names of professors N.P. Durova, A.Kh. Reder, N.I. Makarov and V.I. Kurdyumova, ES Fedorova. They wrote fundamental works on descriptive geometry and engineering graphics. After the October Revolution, Descriptive Geometry developed primarily as applied science. It is possible to single out the following directions of descriptive geometry, which have great applied value in this or that field of technology:

- accuracy of graphical calculations used in various branches of engineering (Kargin, 1946);
- the method of combining from the point of view of the generalized theory of projections (Deshevoy, 1962);
- accuracy of solving problems through graphic calculations of efforts in spatial farms (Rynin, 1905; Rynin, 1907);
- application of the method of spatial geometric places in descriptive geometry (Ananov, 1976);
- linear perspective on an inclined plane (Zmetny, 1941).

During this period a number of classical textbooks on descriptive geometry and graphics were published. Let's name the authors of some of them: D.G. Ananov (1976), N.A. Glagolev(1936), V.O. Gordon (1971), N.A. Rynin (1905).

The Soviet period is characterized by the fact that independent departments were created in higher educational institutions, uniting all kinds of graphic disciplines. The Mining Institute is the first higher technical educational institution in Russia, from the first days of its foundation introduced descriptive geometry and engineering graphics into the training program for young mining specialists. This subject was taught along with other disciplines, which can be conditionally

combined under the title "Applied Mechanics and the Foundations of Mechanical Engineering".

It is interesting to note that the day of the creation of the Mining School is October 21, 1773, and its opening was held June 28, 1774 - the day of the accession to the throne of Catherine II.

The chair, at which the Descriptive Geometry was taught at the Mining University, was distinguished by outstanding scientists at different periods of time, who gained recognition not only within the walls of the Mining Institute. Among them, Christian Leschenkol (1774-1791) - the first leader, I.N. Wolgemut (1799-1831), G.K. Langsdorf (1831-1834), I.A. Time (1870-1871), A.P. German (1914-1915), L.B. Levenson (1915-1931) (Department of Descriptive Geometry and Graphics, 2017).

Among the scientists who made the most significant contribution to the development of descriptive geometry, it should be particularly noted Academician E.S. Fedorov (1853-1919), who taught at the Mining University. On the example of solving the problems of mineralogy and crystallography, he showed the applicability of graphical methods to the study of the laws of the material world. More than 30 years (1932-1965), the department was headed by Professor A.A. Shchukin. He is a well-known, talented and original think scientist, a major specialist in the field of mining engineering.

In Russia, the first standards containing the rules for the implementation of engineering drawings were published in 1928 and repeatedly revised and supplemented. Currently, all technical drawings are carried out according to the rules defined by the complex of state standards (GOST) called "Unified system of design documentation" (ESKD). Compliance with these rules is mandatory for all organizations and individuals (Ignatyev & Levashov, 2012)

In 1935, the Department of Mechanical Engineering was renamed into the Department of Applied Mechanics and Graphics. And in 1965, as a result of the reorganization, taking into account the importance of discipline in training, into the independent Department of Descriptive Geometry and Graphics. The first head of the Department of Descriptive Geometry and Graphics was Associate Professor N.F. Alekseev (1965-1985). During this period the associate professors G.V. Krunchak, G.M. Deshevoy, N.A. Kondratiev, E.D. Ryabkov, Yu.N. Popov, A.I. Kirichenko, N.N. Smirnov; Professor V.D. Zinevich, P.V. Filippov, who later headed the Department of Descriptive Geometry of the Higher Leningrad Naval School. It should also be noted senior teachers V.S. Mukhachev, A.G. Andreeva, V.V. Dugin, V.R. Langner and assistant VM. Kuznetsov. Doctor of Technical Sciences Makhovikov B.S. worked as a professor at the department for 13 years (from 1961 to 1971). For a long time (1985-2005), the Department of Descriptive Geometry and Graphics was led by Professor, Doctor of Technical Sciences Nikita Evgenievich Bobin. To this day - Yury Dmitrievich Muraev, Doctor of Technical

Sciences, transmits his experience to colleagues and the younger generation. At present, the staff of the department is a worthy receiver of the traditions of the Soviet and Russian schools in the field of teaching and training young specialists at our university.

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

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 (Bakalavr/Magistr) 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 (Russian Education, 2017).

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. Existing studies generally showed that the population of Russia as a whole appreciates the exam, including the latest innovations associated with it Voronina et al., 2016). 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 have 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.

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 Suzuki K. (Suzuki, 2002) and Kondo K. (Kondo, 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

Saint 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; Tretyakova &Voronina, 2015; Voronina et al., 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 (Surinkova, 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 (Heifetz, 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 Heifetz A. L. 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[1], 2012). 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 Saprykin D. L. 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 (Saprykin[2], 2012). Moreover, in his investigations Saprykin 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 (Saprykin, 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 H. Stachel (1994 b). 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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