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REASONS FOR THE DECREASE IN THE LEVEL OF GEOMETRIC GRAPHIC SKILLS OF STUDENTS: CONTRADICTIONS AND WAYS OF THEIR SOLUTION

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Abstract: The article presents the results of the analysis of the causes of the current situation in teaching engineering graphic courses in the higher professional education. Contradictions are revealed and possible ways of their solutions are planned.

Innovative high-tech engineering is impossible without a sufficiently high level of formation of professional competence, creativity and responsible attitude to solving business problems and entrepreneurship and communication skills. The basis of engineering and technical education provides training in the field of geometrical graphic disciplines. The level of professional competence and competitiveness of the graduate of technical university largely depends on the quality of the geometric and graphic education.

At the same time, many educators and researchers have noted that the level of geometrical graphic preparation have declined in recent years, which negatively affects the level of assimilation of other technical and special subjects, and eventually leads to a decrease in quality of engineering education.

The problem is particularly acute due to reduced training time available for the geometrical-graphical training that is of a special attention of researchers.

We analyze the main reasons; for convenience of the analysis we divide them into four groups. The generalized scheme is shown in Fig. 1 (numbering in the text corresponds to numbering of blocks in the scheme).

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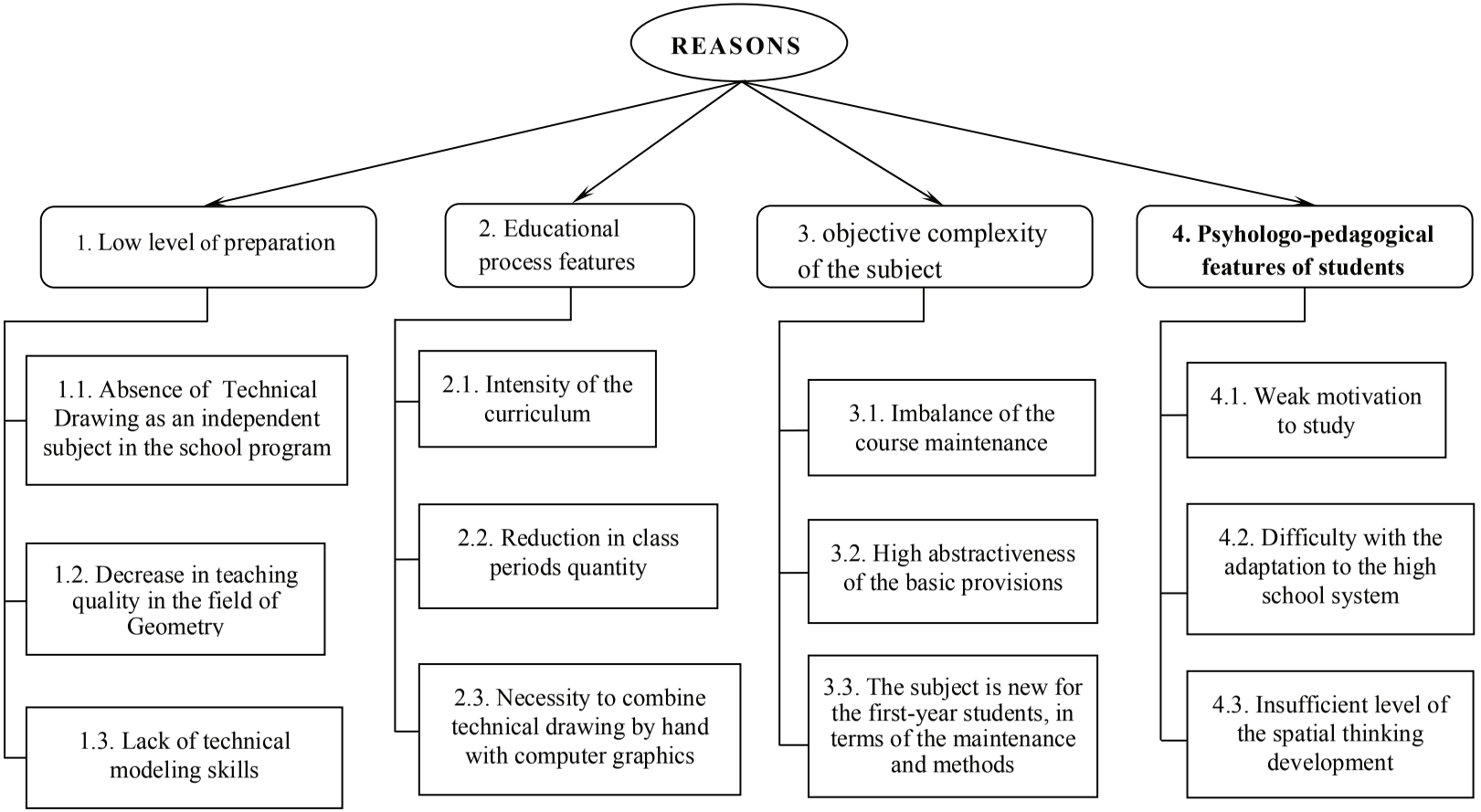

Fig. 1. Structurally – hierarchical scheme

1. The first group of the reasons is due to the low level of preparation of school-leavers.

1.1. Lack of basic (school) training in drawing, poorly developed spatial and logical thinking, imaginative fancy. Many first-year students have no basic knowledge of Technical Drawing. One reason for this is that the secondary school level graphic preparation of students decreases every year, and then simply vanishes. According to L.V. Turkina: "Recently, we are faced with the fact that graphic knowledge of secondary-education institutions is at a low level, it is because the course "Technical drawing" has become elective in the school curriculum, and many schools have excluded the subject "Technical Drawing" from the training programs or integrated it into the course "Technology"" [1].

The chief designer, Doctor of technical sciences, M. Kalashnikov paid attention to the alarming fact of the narrowing technical component in the comprehensive school program. In his letter [2], he writes that even "at school" learners must acquire a certain level of knowledge and skills in engineering graphics. According to him: "Further reductions in the technical direction of the school program may soon lead to lower initial level of training of students of technical universities, which will cause the loss of the capacity of the Russian engineering school".

The fact that Technical drawing was not included in the curriculum as an independent academic subject, in the opinion of T.E. Tikhonov-Bugrov [3], V.V. Stepakova, A.I. Kuharchuk [4] leads to the fact that no one is engaged in the development of spatial imagination, the ability to change the view of the object, to move mentally from the representation of a part (model) to flat projections and vice versa, and, therefore, these skills in school children are not formed.

As a result the students who enter technical universities do not have basic graphic skills, do not know the rules of technical drawing. This complicates the process of students' perception of graphic educational information and teachers are forced to search for different ways to enhance and intensify the process of preparing the graphics at the university.

Students, who did not have sufficient and high-quality graphic preparation at school, need extra study, conducted during extracurricular time. This creates an additional workload and as a consequence, the fatigue of students.

All of the above indicates the need to consider graphic education as a necessary component of general education that meets the principles of humanization humanitarization, cultural congruity, providing communicative and technological education of students.

1.2 In contrast with the course of Technical Drawing, the course in Geometry is included in the core curriculum (**CC**) of secondary school, but the quality of students' training in the field of geometry has also reduced in the last few years. In the publication [5] on the current situation on the problematic issue the lecturer of MSTU named after N.E. Baumann, V.N. Kalinkin reaches the following conclusion: "The claim that geometric preparation of secondary school graduates is at an unacceptably low level, has become commonplace. First-year students of technical universities are often unable to solve the simplest problem in plane geometry, not to mention the stereometric problem of average complexity. The simplest spatial transformations for a substantial majority of students are a daunting task".

The key reason for the decline in the knowledge of geometry is the exclusion of geometric tasks from the final examinations in mathematics. According to the experts D.E. Tikhonov-Bugrov [3], S.I. Pavlov and Yu.V. Semagina, [6] newly adopted educational standards for secondary education, even make things worse. The federal component of standards does not include the requirements of the theorems formulations knowledge and the ability to prove them, abilities to deduce the formulas, – that is the basis of the mathematical method.

Instead, it is proposed to provide examples of evidence. Much of the material in the new standards is set in italics, which means that it can be omitted at the discretion of the teacher. Replacing the study of the subject with an introduction to its contents is similar to the replacement of intensive training with an extensive one. This is absolutely unsuitable for the natural sciences, based on an accurate description of the concepts, knowledge of the sequence of logical chains, proofs. It is difficult to disagree with this opinion of the authors.

All this leads to the university students' opinion that the graphic subjects are second-rate ones, which negatively affects their willingness to learn geometric-graphic subjects.

1.3. Absence of the technical modeling skills is the result of many links missing in the chain of young people's education.

Some time ago there were “palaces of pioneers”, various industrial complexes with technical classes and clubs which promoted the development of technical interest of schoolchildren and youth.

Today all these have been moved to the background or even lost at all. And after all, it used to be one of the components of the development of technical modeling skills, engineering mentality, technical vision and technical culture as a whole.

As a result, the yesterday's entrants with low-developed geometric graphic and technical skills become today's first-year students that are absolutely unable to comprehend engineering sciences.

2. The second group of reasons is due to the peculiarities of the educational process, which should include, above all, the strength of the curriculum, reducing the number of training hours, the manifestation of trends of combining pencil technical drawing “by hand” with computer graphics.

2.1. Currently, Descriptive Geometry is represented in the curriculum with a comparatively small number of hours taught primarily in the first semester of study.

By analyzing the content of the 2nd Generation State Educational Standards for different engineering specialities and comparing them to the same specialities in the curriculum, it is clear that the recommended duration of graphic courses has been reduced while the final requirements to learners, on the contrary, have increased.

To prove this fact V.E. Shebashev, in his review on the State Educational Standards [7], notes: “Sometimes requirements of the State Educational Standards and syllabi for various professions are in conflict with the generally recognized principles of didactic teaching. It is not possible to speak about the level of the geometric-graphic skills and ways of practical implementation of the principles of graphic subjects studying sequence because on some specialities, for the studying of all three sections – Descriptive Geometry, Engineering and Computer Graphics, the State Educational Standards provide

51 hours in one term i.e. 17 hours on each section. Certainly, it is easy to achieve the goal at the information-fact-finding level, however it is hard to provide the serious practical preparation at such speed of each section mastering during 1/3 semester".

2.2. Reduction in the quantity of academic hours on studying of Descriptive Geometry and other common technical subjects leads to the fact that a number of units is taught and studied only at the level of concepts. The tendency of the reduction of hours for in-class and independent work with the simultaneous conservation of the total amount of knowledge and skills which the student should seize at subject studying, demands special skill from university lecturers.

Obviously, it is useless to expect the increase in the amount of time to study the discipline, given the current trend. But more effective learning will not happen if the selection of the content of the course will be based on the principle of reducing pre-existing, so-called "full" courses. We currently observe the results of this approach to planning the educational process [8].

2.3. Manifestation of the trend of combining technical drawing with a pencil "by hand" with computer graphics, and in some cases its replacement is considered in many publications on professional graphics education. The controversy of this subject focuses on two aspects.

On the one hand, there are adherents of radical modernization of the well-established training course on graphic disciplines which stood the test of ages for many decades. They offer to withdraw the so-called "out-of-date" traditional graphic courses from the curricula.

This opinion is held, for example, by Professor A.P. Tukanov, V.A. Rukavishnikov, S.A. Morozov, R.G. Gazizulin. They talk about the necessity to replace three sections of the geometric graphic course for technical colleges by a single course "Engineering geometrical modeling".

The authors of the publication [9], V.I. Yakunin and G.S. Ivanov did not stand aside and took part in this debate; opposing their colleagues, they expressed the following: "On the contrary, in the present conditions of global computerization, the need for solving complex scientific and technical problems, creating the conditions for training of highly qualified engineers and scientific personnel it is advisable to share complementary methods".

The results of the debate were summarized by I. Borovikov in the theses [10] devoted to the problem under discussion. In his words: "The rapid development of computer technology has identified the need to use computer technology in the geometrical-graphical training of future engineers. It would be naive to oppose it. It is unlikely that a modern engineer thinks without computers. But to exaggerate the importance of computers would be dangerous".

In our opinion, computers should not overshadow the content of a scientific discipline. There are a lot of negative examples, when a student has good command of computers, but cannot do simple computing operations without it. Unreasonable use of a computer will help the hands, but do great harm to the head. *The computer, being the tool*, should help with the subject mastering. And the change of the working tool doesn't assume the replacement of one science by another at all. On the contrary, there is an extension of the scientific knowledge, strengthening of the sciences. The solving problems on the basis of

the computer would help students to avoid some routine graphic operations and make the process creative. But the fact of the computers use doesn't mean that traditional graphic subjects, such as Descriptive Geometry, the Engineering Drawing and Technical Drawing should be immediately replaced by Machine Drawing or other similar courses.

3. The third group of reasons is caused by factors that characterize the objective complexity of the subject, such as the imbalance of the course, the high abstraction of the main provisions and the novelty of discipline, both in content and in methods.

3.1. The first reason, which belongs to the third group, is characterized by an imbalance of the course.

Reducing the number of training hours for the course in Descriptive Geometry leads to the fact that it is very difficult to build a complete logical presentation of educational material. The teachers have to break the balance between separate sections of the course. Even the important sections of the course have to have to be given a “denominative" manner”, without explaining the material in details.

The State Educational Standards give a full list of the topics of the subject “Descriptive Geometry, Engineering Drawing», including all possible sections. It makes an impression that the author of this part of the State Educational Standards took the old good textbook on Descriptive Geometry and copied the whole table of contents. . And it would be OK if more hours were allotted to study all these topics. Any lecturer of graphics will understand that the proposed number of hours is not sufficient for studying the discipline in this volume. Therefore, lecturers are compelled to reduce the course again. However, the aim of the subject is to develop spatial thinking.

3.2. The distinguishing feature of the content of the course "Descriptive Geometry" is the high abstractness of basic provisions. Creating descriptive geometry, Gaspard Monge oriented it to the solution of practical engineering problems. While working, Monge introduced the abstract geometrical concepts such as point, straight line, and plane surface. The introduction of these concepts was necessary in order to identify common geometric elements, concepts and methods of solution in all the variety of practical applications. Thus, descriptive geometry has become a science dealing with the abstract concepts of points, lines, plane figures, surfaces, etc.

The image which helps the person to explore the world around him much faster essentially influences mastering of new knowledge.

The images in the graphic activity are the specific forms of the reality reflection. They are created by means of Engineering Geometry and Drawing.

All the history of Descriptive Geometry and Engineering Drawing is accompanied by the visualization of concepts which is expressed by special system of signs. The graphic image is the form of some visual statement used by engineers as a “drawing language”. The graphic image is the basic operative unit of the spatial thinking in which the spatial characteristics of an object (i.e. the form, size, interrelation, arrangement on the plane or the space concerning any reference point) are presented. The visual representation can be real, symbolic or abstract.

Unfortunately, first-year students, as a rule, perceive abstract images and ideas with great difficulty; it is easier for them to work with concrete, “tangible” things and subjects. The development of abstract, figurative thinking could be promoted by the school course “Technical Drawing”, as well as school and university courses of logic, but these courses often aren't included in curricula.

3.3. Considering the process of learning graphic disciplines with different perspectives, one cannot ignore the fact that Descriptive Geometry is one of the most difficult disciplines for undergraduate students at technical universities.

There is a need to analyze why Descriptive Geometry is one of the most difficult disciplines.

The detailed analysis is made by the following researchers: N.V. Myasoedova [11], L.V. Andreeva [12], K.A. Volkhin [13], A.E. Lukinova [14], G.A. Ivashchenko [15] and many others.

Firstly, it is explained by the complexity of the course in descriptive geometry itself. However, I cannot agree with this completely. The descriptive geometry course taught at universities has been simplified considerably, in comparison with the current program of the courses taught at universities before. So, the content of the course “Descriptive Geometry”, functioning at higher educational institutions in pre-revolutionary Russia [16], provided the studying of such questions, as the theory of shades, prospect, the theory of brilliant points, i.e. questions which aren't studied now at universities. In our opinion, it is necessary to explain it by some objective and subjective reasons.

Secondly, the problem is becoming more complicated, when the subject matter is offered to former schoolchildren. For them it is a new subject basically, in terms of both the content and methods. The subject is just difficult for perception.

The content of the secondary school subjects, such as physics, chemistry, mathematics and other subjects have the logic continuation i.e. corresponding courses at university, but Descriptive Geometry does not have such close connections with the subjects studied by schoolchildren.

It is not correct to consider the course of Stereometry, studied at the secondary school as the predecessor of Descriptive Geometry though its certain positions are surely used. The point is that Stereometry examines a specific body, while drawing is given a supporting role, and it is performed only in the axonometric projection, as a rule. Descriptive Geometry first of all does not study any certain shapes, but abstract points, straight lines and planes that demand the corresponding reorganization of the trainees thinking.

4. The fourth group of reasons is caused by psychological-pedagogical features of students and is presented by their weak motivation for studying, difficulty with the adaptation to university system and the insufficient level of spatial thinking development.

4.1. The graphic subjects in technical universities are, as a matter of fact, the first engineering subjects studied by students at university. The efficiency of the engineering subjects study depends on the previous knowledge of graphic subjects. In this connection, according to the authors E.P. Dubovikova, L.I. Khmarova [17], motivation is one of the key components improving the quality of educational process in terms of common technical and graphic subjects.

It is necessary to mention three basic factors which influence the absence of the first-year students' motivation for studying:

1) weak students' progress on the basic subjects, such as Mathematics, Physics, Descriptive Geometry etc., can be explained by the fact that the student doesn't directly correlate these subjects with his future speciality and considers them as second-rate. That is why there is no wish to study the subject;

2) in the conditions of market economy it becomes difficult to predict what kind of experts will be required in five years, so students are not fully aware of what they will do after graduation. This uncertainty gives rise to an indifferent attitude towards their studies at university, because the goal is a prestigious university diploma, rather than knowledge;

3) insufficient career counseling of the high school students leads to the fact that they often choose a profession at the urging of their parents or school friends' adsvice. In this case, they tend to get disappointed with the future profession and are reluctant to study hard over the next five years.

According to T.V. Chemodanova [18] "…being a difficult self-organizing system, the student starts to work, if he is interested in something. It is noticed that the interest to a studied subject is realized by students earlier, than other motives of the study and are guided by them in their activity. But it does not mean that only interesting subjects must be taught. Getting knowledge is the work demanding many efforts.

That is why it is necessary to stimulate and encourage the student's interest to the studied subject because the development of spatial thinking, figurative thinking and memory are obligatory and necessary conditions for the development of his professional qualities.

4.2. Moreover in high school Descriptive Geometry is studied during the first semester i.e. when the first-year students haven't got used to the high school learning techniques yet, i.e. listening and taking notes of the lectures, planning and organizing of the independent work and leisure, organizing the working place etc.

Making comments on a current situation in one of his publications [19] A.N. Filin ascertains: "During the first months of studying at university, the students aren't able to organize the preparation for classes properly, have no skills of working with various educational, referential and methodical literature. This factor considerably complicates the teachers' work that involves the tense teaching process and rigid control.

Moreover the following specific features of Descriptive Geometry should be taken to account: strong interrelation of sections of the program, fast increase in the complexity and obligatory understanding of all sections of the program in the strict sequence.

Insufficient readiness for the university training, ignorance of the training techniques, are the certain obstacles in the study of Descriptive Geometry for many students.

Therefore the primary goal in the initial stage of teaching is the establishment of the volume, type, form and places of the work with simultaneous provision of the students with the methodical help, stage-by-stage control and an estimation of the performed work results.

4.3. One of the students' graphic culture components is the development of **spatial thinking** which provides the “practical and theoretical” orientation in space (I.S. Yakimanskaya's terminology), effective acqusition of knowledge, mastering by various kinds of activity. Modern psychologists make a note of the high efficiency of spatial thinking caused by the large informative capacity of images.

Spatial thinking is important in a variety of design and engineering, technical, inventive, graphic activities. For the conventional perception of graphic images people should possess methods of their creation, be able to review and consolidate the image data in a design document, mentally transform flat shapes of the drawing into volumetric one (and vice versa), to move the created object in space.

The basic mechanism of spatial thinking, according to T.V. Andryushina [20], is the activity of representation, and its content is manipulation of images and their transformation. Words are means of conversion. Graphic representation carries out an aesthetic mission as well as as well as the functional one.

Descriptive Geometry in most universities is studied only one semester. This is a very short period of time for the discipline that requires a lot of attention and concentration, abstract thinking. V.I. Kurdyumov in the introduction to his course in descriptive geometry, defining it as the grammar of language technology, wrote that the subject study has both educational and pedagogical: it develops imagination without which there would be no technical creativity, i.e. designing.

A special challenge for most students in a course in descriptive geometry is the mental manipulation of spatial figures. This is due to the fact that only 30% of the world's population is endowed with a spatial representation of birth, and 70% has to develop it. That is why for the majority of students this problem becomes more or less solvable and for some of them it remains a great problem until exams. Therefore it is not accidentally that students, having faced such difficulty, become indifferent and even hostile towards the Descriptive Geometry study, and they learn the material mechanically only to pass the examination.

To sum up, we formulate the fundamental contradictions inherent to teaching of Descriptive Geometry in a technical university at the moment:

– disparity of educational time to study graphic profile courses and the amount of academic hours for the study listed in educational standards;

– the need for learning all the necessary information of increasing size, complexity and the required quality of education;

– Disparity of the level of graphic preparation of students and their ability to perceive the course material that meets the requirements of higher education;

– students' inability to rationally plan their own learning process in terms of allocation of time for independent work on the assimilation of the studied material;

– reduction in student motivation to quality education in a changing social orientation and increase in the quality requirements for training;

– great didactic possibilities of modern computer use and lack of quality electronic textbooks on the discipline.

Thus, there arises the problem of organizing such forms and methods of training that would help resolve these inconsistencies and improve the learning process.

In connection with the above there is an acute problem of the need to develop such teaching materials, teaching methods and teaching itself, which will make it possible to solve, or at least to reduce the severity of identified problems.

Proceeding from the results of the analysis of process of teaching the geometric graphic subjects in technical universities, it is clear that in order to overcome these contradictions and identified problems we need to actively seek ways to improve students' educational and cognitive activities.

The above described tendency forces to set a number of general tasks:

1) actively search such possibilities of the educational process organization which could maintain and raise the experts' level of graphic skills in the condition of the shortage of means and time;

2) help first-year students to adapt in the training process;

3) help students to develop the skills of independent work, including the work with mechanic and electronic devices;

4) help students to organize learning activity so that to essentially save efforts and time.

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Причины снижения уровня геометро-графической подготовки студентов: противоречия и пути их разрешения

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Ключевые слова и фразы: анализ причин проблем; возможные пути разрешения; выявление противоречий; графические дисциплины; инженерная геометрия.

Аннотация: Приведены результаты анализа причин ситуации, сложившейся в преподавании инженерно-графических дисциплин в высшем профессиональном образовании. Выявлены противоречия и намечены возможные пути их разрешения.
