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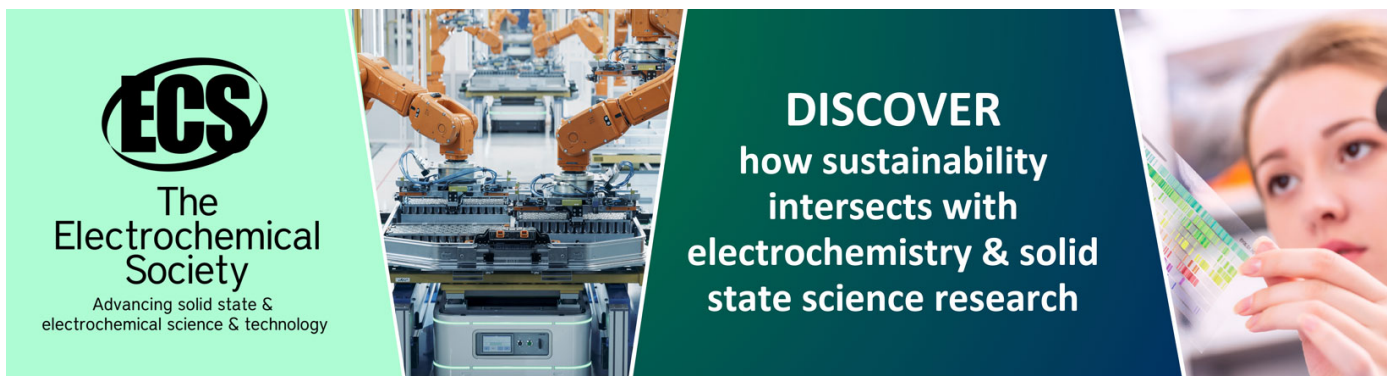
Adaptation of Polytechnical Education to Industrial Production

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Adaptation of Polytechnical Education to Industrial Production

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Abstract. Insufficient level of professional training of engineering personnel is noted. Factors affecting disbalance of links between modern vocational education and real engineering practice are given. Young engineers engaged in design and development do not have enough modern instrumental training in the field of information technology, as well as interdisciplinary knowledge and system competencies to use technologies for the full life cycle of innovative products. In professional training of technical personnel, the changes aimed to shorten adaptation of young specialists in the workplace and encourage the speedy introduction of methods and technologies of digital economy into engineering practice are imminent. An overview of innovative approaches used in training of engineering personnel by leading Russian universities is given.

Graphic training is the first discipline in technical students' professional orientation. In the context of substantive training, it is important to create a learning environment that is close to the professional one. Examples of practice-oriented study assignments based on the method of projects implemented by students in the course of independent work are given. Innovation in the development of individual tasks is possibility to execute projects in 3D format. Effectiveness of the proposed innovative training technology is confirmed by the given statistical data.

1. Introduction

For substantial development and modernization of the Russian economy on the basis of digitalization, technical re-equipment of high-tech industries is required. To implement this large-scale task, we need qualified engineering personnel capable of generating new ideas, effective solving current production problems and bringing them to a commercial result, transforming ideas into design and technological solutions on the basis of the latest information technologies [1]. At the same time, many employers today notice a decline in the level of professional training of technical personnel [2]. The reason for this, perhaps, is vagueness of the declared goals of the reforms conducted in education, the focus of which should be the system of training of competitive specialists in the polytechnical profile. Among the factors influencing the imbalance of links between training and production, the following [3-7] can be distinguished:

- transition to level training in higher education: mass acquisition of bachelor degree and selectivity of master's training, which reduces the overall level of "technical education" of graduates;
- general decline in the quality of secondary education, an emphasis on humanization of the educational process, and the secondary nature of technical orientation subjects, which, in general, leads to decreasing the prestige of polytechnical education;



- inconsistency of the educational programs' content with the labor market demands and the equipment of modern production complexes;
- insufficient equipment of universities with modern facilities and software;
- obsolete educational technologies, aging professorship, weak training of teachers in using the latest information technologies, low prestige of the scientific and pedagogical career;
- isolation of science from engineering education;
- insufficient demand of scientific potential of universities for business and industry, small volumes of research and development, weak relationship between the educational process and the real environment of production activities.

All these problems lead to a gap between modern vocational education and real engineering practice, which will only grow with time. What requirements for graduates in the field of engineering, technology and technical sciences are pressing in this situation? Today, most of engineering activities are related to design functions of technical specialists [8]. Young specialists should have a wide range of engineering, applied and economic competences, including interdisciplinary and management knowledge, to use them in designing innovative technical systems and mastering new production technologies [1].

Training of engineers in the era of digital economy is, on the one hand, the most important factor in the success of economic development, and, on the other hand, requires a radical change in the educational process [9]. For the most part, the developed programs of higher polytechnic education, as well as the applied educational technologies, both in the general course of study and in mastering certain disciplines of the professional cycle, do not solve the task of training competent and competitive specialists for the Russian innovative economy. Young engineers engaged in design and development do not have enough modern instrumental training in the field of information technology, as well as interdisciplinary knowledge and system competencies to use technologies for the full life cycle of innovative products [10, 11].

2. Innovative approaches in training of engineering personnel

In professional development of engineers, their rapid adaptation to the production conditions plays an important role. The process of production adaptation is focused on operative adaptation of the employee to the changing conditions of labor activity, on successful interaction with the production sphere. It is also connected with the desire to competently demonstrate their abilities and aspiration to career growth. Development of the future young specialist' skills for industrial adaptation should be supported by the creative atmosphere of the educational process in the university: widespread use of innovative educational technologies that immerse the learner in a quasi-professional environment; application of active technologies that stimulate cognitive activity of students and develop professional interest in the future profession; adaptive management of forming the professional competence process, taking into account the trainee's personal characteristics [9, 12, 13].

Today, along with adopting a number of decisions at the highest state level aimed at the development of engineering education, innovative approaches to modernization of the educational process for training young specialists demanded in the modern production sphere are already being introduced in some leading technical universities in Russia [4]. On the basis of the interdisciplinary approach, new models of training are developed and processes that form specialized competencies for future graduates and cadres of Russian enterprises are being implemented [5]. Universities create a virtual environment for engineering activities as a network of automated workplaces for engineers and operators [2]. Russian universities are increasingly using the CDIO's international approach to engineering education [14, 15]. In order to make the learning process closer to real design and development activities, the CDIO ideology ("Conceive-Design-Implement-Operate") should be used already in the early stages of training [16].

In our opinion, the use of end-to-end engineering technology for educational programs that train bachelors and masters in engineering and engineering directions of innovative orientation [1] deserves attention. This technology is considered as a set of methods, techniques and means of organizing the

educational process, along with optimizing the structure and content of the educational program, which provides an interdisciplinary process of mastering design technology on the basis of the complete life cycle of technical systems in accordance with the training profile. This method is based on introducing an integrated project task, which is performed by the student for several semesters and is the unifying factor between disciplines of the educational program. Mastering the educational program, the student consistently creates a project of a real technical system related to future professional activities of the graduate. In this case, the educational project activity integrates the content of the educational program and assigns a vector to the overall vocational training. The graduate forms his professional competences in the design and technological activities necessary to create future innovative projects.

In training of engineering personnel, the project method has proved itself quite well [17, 18]. The method of projects in the educational process creates conditions that allow students to get involved in solving production problems and begin practical activities related to their professional sphere. Project work can also find its application in junior training courses. In this case, at the initial stage, when mastering general professional disciplines, students are ready to solve real practical problems, they develop ability to integrate specific disciplinary knowledge and skills.

Effectiveness of using the project method largely depends on the possibility of creating appropriate conditions for learning activities under which the engineer's real professional activity is modeled. Providing such conditions, especially in the early stages of training, is not easy. Peculiarity of engineering activity in each of the industries is associated with complex and specific technologies and their rapid updating, and while organizing the learning process special attention should be paid both to the content of teaching and methodological materials and to the specialized use of computer technology and information and communication technologies.

It should be noted that with the development of computer technologies in modern engineering activities, especially in designing new competitive products, the role of geometric modeling increases, and with it the importance of geometric-graphic education in technical colleges increases when solving the problem of its practical orientation [19, 20, 21].

In this paper, we present the experience of improving the content and design-oriented implementation of geometric-graphic training for students of Perm National Research Polytechnic University on the path of convergence in the areas of training and production activities.

3. Adaptation of geometric-graphic training to the production activity

Within each substantive education, the innovative orientation of the learning process in the university should be aimed at comprehensive developing the student's personality, his needs and interests, both universal and professional. At the same time, as it was mentioned above, for immersion in the atmosphere of future professional activity, it is important to set up a practice-oriented training course at the initial stage of education.

With the purpose of creating the learning environment for adaptation of students to real engineering activity, the authors develop and introduce innovative technology of geometric-graphic education. We can note the following distinctive factors of the proposed training methodology:

- wide use of computer technologies at all stages of the learning process (mastering theoretical knowledge, developing practical skills, forming the competence of modern instrumental training of designer) and simultaneous enhancing the role of computer graphics as a specific section of this subject area;
- formation of scenarios for professional situations in tasks, assignments, projects;
- transition from the study of abstract geometric objects to real ones, corresponding to the profile direction of the engineering training program;
- adjustment of a reasonable balance between theoretical training and design practice, especially strengthening the latter;
- formation of specialized information libraries, including prototypes of typical solid-state models of objects necessary for working at educational projects;

- introduction of team forms of student's work in project activities.

Here is an example of a design task for independent work of students in the architectural and construction direction of education, which is performed at the initial stage of geometric-graphic training while studying the topic "Surfaces". The aim of the project task is to develop the students' following competencies based on CDIO ideology: to analyze a set of conditions (reflection phase and planning), to select the option (preferably the best one) (design stage), to create a virtual 3D model of the object using the obtained geometry knowledge and modern instrumentation (implementation phase), to draw conclusions and recommendations (application stage). The applied orientation of this work is connected with studying the structures of dome forms, which are widely used in real building and architectural compositions (see Fig. 1).

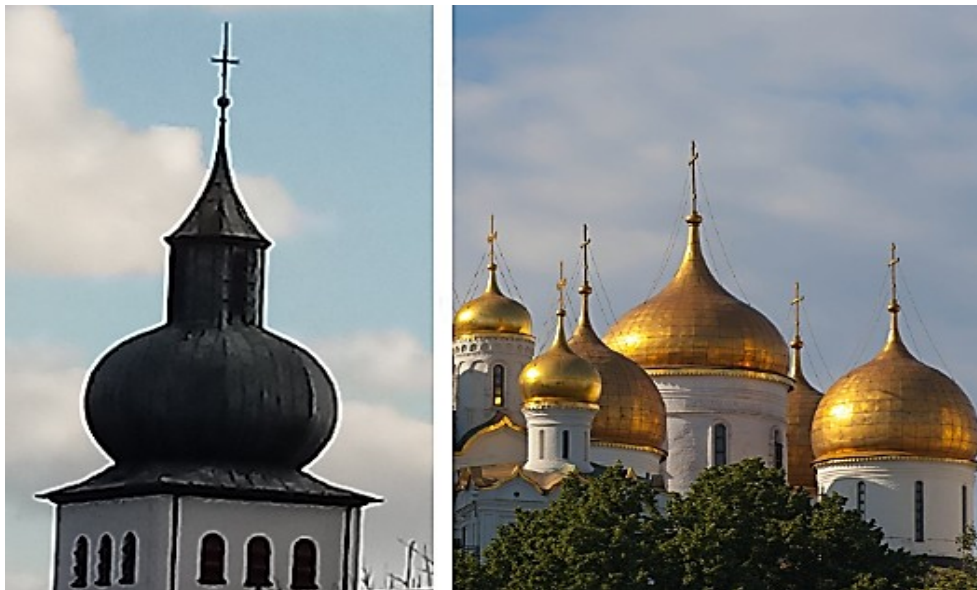


Figure 1. Varieties of dome forms: on the left - early architecture; on the right - modern domes in architectural structures.

Table 1 shows variants of tasks for designing typical models of domes, consisting of different sections of surfaces and having different design conditions. For each of the above options, the algorithms of geometric constructions are demonstrated when creating a sketch of the dome's contour and the resulting virtual models are shown.

A more serious methodological approach for project competence formation and creation of an "industrial" training atmosphere is required for students of machine-building directions. Integrative activities of students in implementation of practice-oriented study assignments should be provided with innovative methodological and technological support, including:

- optimal selection of designed engineering objects;
- electronic base of parametric models of the component parts of the object;
- electronic reference library with a set of specialized data on standard products;
- technological maps of stage-by-stage design of the object;
- management of the students' academic work and control of the developed projects.

When implementing such projects, one can use a collective approach (a mini-team of 2-3 students). In this case, for successful work at a common project, both interaction of students and the individual work of each one is necessary to detail their parts of the project. Such an approach also contributes to creating a real atmosphere of project activity.

Fig. 2 shows an example of implementing the project for developing the model of "Reverse valve".

Table 1. Examples of tasks for designing dome shapes.

No	Formulation of the task	Sketch	3D Model
1	Given the parameters, create a dome model based on the classical "golden section" algorithm.		
2	Create a model of a dome limited by surfaces of rotation: parts of a cone that has retained its parameters, and parts of an unknown sphere, provided there are two common parallels.		
3	Create a model of the dome limited by the surfaces of rotation: parts of the cone that retained its parameters, and parts of the unknown torus surface, provided there are two common parallels and the overall diameter of the object.		
4	Create a model of a dome limited by rotation surfaces: parts of a cone that has retained its parameters and parts of an unknown torus surface, provided there are two lines: a common touch parallel and a support circumference.		

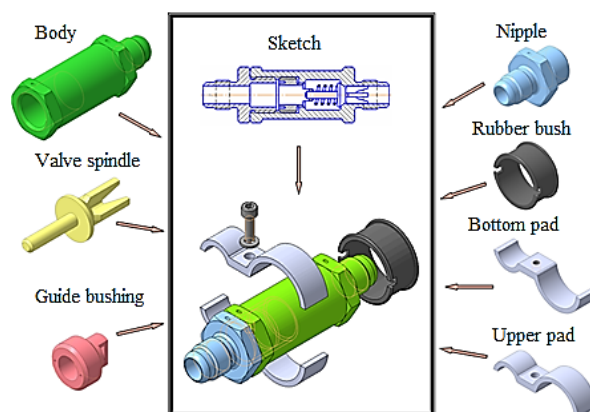


Figure 2. Presentation of design development of the product model "Reverse valve".

The task involves the following steps:

- selection and analysis of the general form of the prepared prototype product to form the model of the proposed construction;
- development of parametric 3D models of typical parts of the projected object and including them in the electronic database;
- execution according to the specified functional and geometric characteristics of the object its overall layout with linking of the relative position of the component parts and the elements connecting them;
- creation of 3D model of the assembly unit; checking its assembly ability;
- preparing report-presentation on the work done.

The proposed practice of immersing students in the atmosphere of real project activity raises the level of knowledge systematization, contributes to increasing professional orientation of graphic disciplines, forms stable design and engineering skills of students, which are in demand in the future engineering creativity while modeling polytechnical products.

4. Conclusion

Experiments carried out can indicate that for successful adaptation of graduates for industrial production, it is necessary to create conditions for polytechnical training that imitate production, starting from the junior courses. Creation of such conditions within the framework of geometric-graphic education assumes acquisition of the initial practical expertise of the project activity, development of professional thinking, verification of readiness for independent solving of design tasks with modern tools.

Effectiveness of the proposed innovative training technology is confirmed by the statistical data shown in Fig. 3. At the end of the first year of training, a survey was conducted on mastering 3D design technologies. Figure 3a shows the data for 2015 (before introducing innovations in the educational process), and in Fig. 3, b, for 2017, when 3D geometric modeling technology became an integral part of the educational activities of students. It can be seen from the diagrams that the proportion of students with no skills in 3D technology has significantly decreased, and the number of students who have mastered modern design methods has increased.

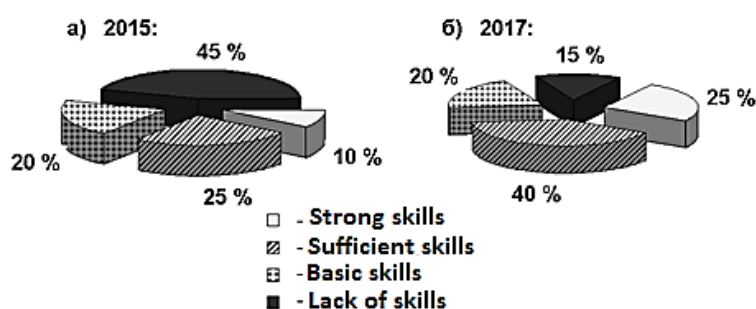


Figure 3. Statistical data of students' mastery of 3D design technology.

As the results show, the methodology and model for implementation of study projects make it possible to change the nature of students' learning activities, enhance their motivation, take into account individual capabilities and needs of production, adapt practical tasks to future professional activity of graduates and stimulate students to deeper mastery of progressive design technologies.

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