Innovative Organization of Project Activity of Construction Students

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Abstract. The construction industry competitiveness depends on its equipping with information modeling technologies. This requires training and development of human resources. The advantages of BIM-technologies are considered. The requirements for the specialists capable of promoting information modeling technologies in the construction industry are discussed. For a wide application of BIM-technologies, the problem of training personnel with a new thinking must be solved. When preparing graduates of the major "Construction", it is necessary to introduce innovative educational technologies aimed at building the students' ability for team work, competences in the field of modern information and communication technologies, as well as design skills basing on spatial modeling. Graphic training is the first discipline of the professional orientation for construction students. In the context of training it is important to create such learning environment that is close to a professional one. The paper provides the examples of practice-oriented assignments based on the project method in the course of students’ independent work.

1. Introduction
Construction industry generates environment for human activities which must meet international quality standards and ensure sustainable socio-economic development of the country. Currently, the Russian construction industry belongs to low and medium-technological areas of the economy and is characterized by a low innovative level compared to high-tech industries and manufactures [1]. Low competitiveness of the construction industry explains its lack of highly professional workers. Increase in competitiveness is a factor of development and sustainability of the sector, it guarantees attractiveness of job placement, population employment and comfortable environment. Taking into account high share of construction industry in the national economy its re-construction will provide a high economical growth of the construction industry and the national economy as a whole, since there is a close interaction of other activities with construction.

Ministry of Construction and Communal Services of the Russian Federation with participation of federal executive bodies and other stakeholders has developed the innovative development strategy for the construction industry of the Russian Federation till 2030 [2]. The aim of the strategy is to create a competitive construction industry forming a safe and comfortable living environment that promotes national security and spatial development of the Russian Federation. It is noted that the basis for innovative development is widespread introduction of information modeling technologies for buildings and structures. To reduce the volume and timing of design and to revive the typical design
system an extensive use of information modeling technologies is planned in architectural and engineering complex [1]. Introduction of information modeling improves management of construction projects’ lifecycle.

Today, there is a very acute problem with competent workforce, including lack of engineers and technicians, a mismatch of the professional training level of university graduates to the labor market [3,4]. Imperfection of educational training programs in relation to modern design technology and insufficient teachers’ knowledge [5] in the field of new technologies are revealed. The problem of developing human resources is also urgent.

This article is devoted to innovative approaches in construction students’ graphic training in the technical university.

2. Advantages of BIM-technologies

Today, building information modeling (BIM - Building Information Modeling) in industrial and civil construction is converting from innovations into the industry standard [6]. More and more organizations in the field of urban development, are not only considering, but also trying to implement a group designing environment and engineering data management. BIM is a modern technology to improve the efficiency of all professionals at all stages of the CONSTRUCTION lifecycle, giving a competitive advantage to the project in today’s market.

In this technology information modeling using parameterization COMES OUT ON TOP. Information is represented not with separate graphic elements (lines, circles, etc.) but with intellectual models (walls, ceilings, etc.) which can be adjusted and modified at any moment [7]. The object is represented not only on a two-dimensional plane, but also in the form of a spatial model with further obtaining necessary plans and sections. In this approach the objects are automatically represented by the totality of the required geometric characteristics, their current location in space is revealed and interconnection is taken into account.

One of the main advantages of using BIM-technologies is the ability to visualize a three-dimensional model filled with information. This allows to visually present the object model and get easy access to any data, from engineering calculations to design drawings [8]. Essential advantages of this technology also include:

- Possibility of joint access and work at the project for all specialists at once;
- Reduction of the transfer time for the necessary working information from one stage to another;
- Updated model relevance when making changes;
- Viewing the object not only in space, but also in time;
- Full visualization at any stage of work at the object.

Application of BIM-technologies allows to obtain deep understanding of the project at every life cycle stage of the object designed: idea, design, planning, construction, use and operation. Such opportunities are a great advantage of the project, as they help to demonstrate and maintain not only the idea and its implementation, but also to predict further process of using the object [9].

To move to extensive use of BIM-technologies highly qualified specialists with new thinking should be trained who can change the situation in the construction industry and raise the efficiency level of design, construction and operation of buildings and structures [4].

3. Training specialists with new thinking

The purpose of the federal education development program for 2016-2020 years is to provide conditions to form the competitive human potential [10]. Among the tasks based on the design-oriented approach to guarantee achievement of the objectives is creation and distribution of structural and technological innovations in professional education, providing high mobility of modern economics and meeting the needs of production and consumption spheres.

The federal standard in higher education establishes the competence-based format of education and the person-oriented education model as an ideological basis. Educational programs having a subject-
disciplinary structure are aimed at forming a set of required competencies agreed upon with employers. In accordance with the standard annual updating of educational programs is provided to keep the education relevant [10].

It must be emphasized that BIM is not "artificial intelligence", and the final result depends on the competent approach and high level professional training. Consequently, the widespread adoption of BIM-technology makes the need for new specialists capable of team work with competence in modern information and communication technologies, as well as ready to carry out innovative projects in 3D ideology [7,11].

Obviously, the current university system will not be able to provide training for civil engineers with sufficient competence in the field of information modeling and innovative organization of work. However, in today's environment it is necessary to ensure readiness of graduates to acquire new computer tools and to adapt quickly to changing design conditions [12,13]. In this connection, there is a need to develop new educational programs and teaching technologies to upgrade their compliance with the requirements of modern design and manufacturing technologies and even ahead of them [14]. The educational process should be aimed at updating the students' cognitive activity, developing creativity and professionally demanded personal qualities.

As the experience of implementing competence-oriented training programs shows[15,16] the most effective educational technology under modern conditions is project training. A number of authors attempt to use models of project-based training in higher school, i.e. practice-oriented education and building individual educational trajectories within the professional training area [14-16].

In training of Construction students the project method requires accounting specific conditions for implementation of this professional activity. As noted in [20], a project in the construction sector should be understood as "a comprehensive system of measures for design, logistical, financial and other provision for construction, reconstruction and modernization, total building renovation, installation, commissioning and other kinds of work, resulting in the final construction product with specified parameters of its consumer qualities, given the restrictions on finance expenditure, connection to power and water supply, etc." Among other professional activities the project competence is the key competence of a construction specialist [14].

It is recommended to develop the curriculum of the educational program "Construction" in accordance with stages of construction project life cycle, and to use design-directed and practice-oriented training within each discipline [3,16]. The higher school activities today should be aimed at "laying a professional basis, coupled with the willingness to continuously learn and develop oneself professionally and personally" [18].

Subject education, including the disciplines of general technical and professional cycles, should be carried out in the environment and in the forms closest to real professional activities. There should be immersion into the future sphere of industrial interests, which will contribute to effective mastery of practical skills and theoretical material [14]. Innovative approaches are needed to ensure integration of systematic subject knowledge with the formed subject competencies as a set of practical skills, abilities, and personal qualities. Modern disciplinary educational-methodical complexes should contain a set of creative and professionally-oriented tasks and problems related to the future professional activity of graduates and directed to obtain necessary competences in the course of education [18].

Graphic training of construction students is the first discipline of professional orientation and implemented in the first year of study in a higher school. In Perm National Research Polytechnic University it is represented by an integrated (united) discipline "Descriptive geometry, engineering and computer graphics" based on geometric modeling [19].

4. Experience in organizing practice-directed activities of construction students within graphic training

For geometric-graphic training of students in the first years questions of project implementation methods are particularly relevant. Firstly, the very profile of such training implies a practice-oriented
professional activity. Secondly, using this method makes it possible to bring educational technologies closer to professional activities of the designer, which does not remain stationary, but constantly undergoes significant innovative changes. Note that the design-oriented activity of students in the given subject area is impossible without using CAD packages, including 3-D technologies [20,21]. Creating a continuous learning environment for innovative graphic training should meet modern requirements. It is necessary to start training and deepen it at subsequent stages basing on widespread use of multifunctional CAD-systems with obligatory participation of 3-D geometrical models of abstract and technical objects of professional orientation.

Within graphic training descriptive geometry and computer graphics are integrated due to the possibility of incorporating conceptual geometric algorithms into the technology of creating abstract graphics by visual 3-D modeling. Training problems based on the synthesis of descriptive geometrical basics and modern tools of virtual 3-D modeling stimulate mental activity and simultaneously develop 3-D modeling skills, thereby providing the required training quality [19].

To a greater extent, educational technologies approaching the real conditions of design developments should be introduced into the discipline "Engineering Graphics", responsible for building up professional design skills and used in further education in the university.

Let us review some examples of practice-oriented assignments in training construction students. Consider the process of creating a 3-D model of the dome shape structure for building and architectural objects. From a diversity of dome shapes (Figure 1) the "onion" shape, requiring rather complex geometric constructions for the curved contour surface of the structure is selected to solve the problem. This project is one of the first practice-oriented activities, performed by students in the course of independent work.

![Figure 1. Examples of dome forms.](image)

In preparing a sketch (Figure 2a) of the future model as an algorithm of geometric constructions the "golden section" law in compliance with architectural canons of cross and dome churches [27]. Visualization of the resulting model is shown in Fig. 2, b. For thorough understanding by the junior students modern prototyping technologies along with designing a virtual model it is possible to demonstrate another opportunity of computer technology, namely printing the object prototype with a 3-D printer.

![Figure 2. Example of a design assignment for an "onion" dome model: a) a sketch of the forming model; b) visualization of the dome model.](image)

Figure 3 shows an example of a design assignment for a specialized product "Roller block" used in construction as an auxiliary equipment. The assembly consists of both individual components and standard products requiring selection according to calculations.
Such projects give an idea of the wide area of design activities in the construction industry. They are almost universal in terms of labor input in geometric and graphic training of students. The project variability involves the following features:

- Changing the assignment for any complexity level – from a simple one (single parts) to context modeling in assembly, including selection of standard products from digital libraries.
- Depending on the project complexity in the educational program the number of tasks can be either reduced or increased, as well as pre-prepared parametrical models of non-standard parts or nodes can be used.
- Changing the number of participants of the project implementation - (one student or a group of students).

This task is performed at the final stage of the students’ basic graphic training. Work at the project contributes to formation of graduates’ readiness to master modern computer tools and develop their construction and design skills. It allows to practice teamwork as well as to demonstrate the level of formation of subject-specific competences as a particular set of practical skills, abilities and personal qualities.

![Figure 3. Example of a specialized project to create a 3-D model of the product.](image)

5. Conclusion

1. Applying BIM-technologies allows to organize life-cycle processes for construction objects at a qualitatively new level. Creation of competitive Russian construction industry is impossible without solving the problem of personnel development.

2. To train demanded technical personnel of high qualification it is necessary to modernize higher education contents and technologies focusing on creating a project practice-based learning environment and using modern design tools.

3. An example of the innovative organization of basic graphic training for construction students demonstrates opportunities of practice-oriented training already in the first years of higher school and contributes to developing competences in geometric modeling.

4. Testing the presented method showed that the updated technologies are perceived with interest by students and they successfully contribute to development of design and engineering competences in accordance with construction industry needs.

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