Engineering and computer graphics for effective training in a construction university

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Abstract. One of the most important disciplines for the training of civil engineers is engineering and computer graphics. However, traditional training in engineering graphics does not bring tangible results, so there is a need for the introduction of modern innovative approaches and methods. It is proposed and justified the use of a combined approach to teaching engineering graphics, based on the combination of three-dimensional modeling in AutoCAD 2018 and traditional, on paper, manually. Studies conducted on the basis of the Kazan State University of Architecture and Civil Engineering have shown the feasibility of using a combined approach. So, as a result of the experiment, it turned out that the most effective assimilation of educational material according to the results of graphic work was demonstrated by the group of students who, when it was used, used both the capabilities of 3D modeling and the ability to manually perform graphic work, with this approach, students receive additional skills, which will become relevant in their future professional activities.

Keywords: education, computer-based learning approach, university teaching, engineering graphics, AutoCAD environment.

1 Introduction

The demand, which is made to the educational grounding of civil engineer, hinge on the development level of the urban planning, construction of industrial buildings and public amenities both of Republic of Tatarstan and over the sea, where the amount of building activity constantly increases.

For that matter a training of specialists on building industry, which meets increased requirements that apply to engineer, is an important aspect. For this reason, a vocational education and training in civil engineering should develop jointly with national social economy, where the demand for specialists continuously soars. Furthermore, innovations in civil engineering both in Russia and abroad require innovations in occupational training [1], as recent educational approaches attest, which are premised on enhanced role of computer technology and smart technology [2, 3]. There is a demand on usage of computer environment, which improves the quality of trainings of specialists of building industry, to promote the innovational educational training programs for experts in building construction. Additionally, computer technology provides an opportunity to organize a self-consistent and individual work of student, and also modern technologies enable to organize a virtual international communication [4], what facilitates an improvement of quality of teaching.

The appliance of computer technology provides with necessary conditions to acquire skills of computer technology experience and technology of future professional practice [5-8]. Nowadays, instructional devices of active learning, which gives good results, is applied to educational programs. An active learning includes: discovery learning, methods of blended learning, experimental learning [9-11]. Actualization of such innovative approaches of learning gives an opportunity to students to a greater degree independently achieve goal, what helps to learn skills required in their future professional engagement [12, 13].
Fundamental, natural-science, mathematical and engineering disciplines are included into the program of education of the specialist to provide with highly qualified education of civil engineer [14, 15].

Moreover, specialists in urban planning mention that both in Russia and abroad, requirements for graduation rise and despite existing wide range of graphics software program [16], which gives an opportunity to design different architectural shapes, adequate verification of design conception requires skills in solving spatial planning of imaginary tasks manually [17-19].

One of the principal subjects of training of specialist in building industry is “Engineering and computer graphics”, where the primary target is development of skills such as knowledge of basic rules of geometrical formation, construction and intercrossing of shapes in plane and space, which is necessary for making and reading drawings of building, constructions, structures, implement construction documents and it’s details. Today computer graphics indissolubly tied to architecture, pure engineering and construction engineering sector. Conventional teaching of graphic engineering doesn’t give appropriate results, therefore, modern innovational methods of training and approaches, informational technologies penetrate the studying process, which gives an opportunity to significantly improve the digestion of teaching material in the subject by students.

This subject is usually studied on the freshman class and it is consist of lectures on projective geometry and engineering graphics, and tutorial covering the same sections and lab sections on computer graphics [20], however, it’s digestion complexifies with a range of parameters. First of all student adaptation to the high school requirements. Secondly, the absence of basic knowledge of technical drawing, because there was a refusal of subject such as technical drawing in Russian schools in nineties. According to the study, which was undertaken by Volkhovin K.A., almost 80% of students in each study group starts to do the subject from point zero [21]. Thirdly, school teaching of geometry is slightly different from teaching of engineering graphics.

The subject of descriptive geometry is a studying of different methods for constructing of images of spatial forms on a plane and methods for solving geometric problems from given drawings of these forms [22]. The person, who is not able to read and elaborate a drawing on a paper, finds is challenging to do it meaningfully on a computer.

It is obvious, that studying of any algorithms of descriptive geometry demands representation of spatial models, which were demonstrated on posters and drawn on a blackboard by teacher, hereafter they were depicted on slides or 3D-figures, drawn up on computer on AutoCAD software. However, students were passive observers and the process of study was not highly effective for them.

The current state of availability of computer equipment in the educational process allows students to actively participate in the learning process, independently creating an illustration of the studied material [23]. There is an opinion, that descriptive geometry will not be essential and traditional design will be outdated once computer graphics is adopted [23]. By the way, the efficiency of computer using definitely depends on knowledge of basic theory of drawings and on knowing when to use them both during the constructing on software stage and handling of applied problems.

It should also be noted that in senior courses students are also required skills on computer and engineering graphics for the competent implementation of term and diploma projects. This determines the relevance of the effective study of this academic discipline. Different teaching methodologies of engineering graphics are in the work, they give consideration to specification of university for the purpose of the best subject acquisition [25, 26]. In addition, in the process of completing the assignment for engineering graphics, students gain skills in drawing up parts drawings, creating electronic models of parts in AutoCAD, as well as in other computer environments [27-29] and working with reference books.

Analyzing the importance of visualization skills in engineering education, a dual approach is offered, which is based on computer graphics applications that use both web graphics applications and a sketch-based modeling system to make improvements to performance capability.

An experimental study conducted at the University of La Laguna, which was aimed to aquire spatial thinking among students, showed the importance of spatial viewing in terms of engineering
education. Existing methods for assessing these abilities from a psychological point of view and attracting the attention of students to the development of two important skills for future engineers: freehand drawing and understanding the relationship between orthographic and axonometric views [30].

Therewith, it is important to mention, that students during their education on “Engineering and computer graphics” also gain skills in computer modeling required in future professional engagement both on the projecting phase and construction phase [31].

The purpose of the study is to substantiate the effectiveness of using a combined approach in the study of engineering graphics by students of a construction university.

The object of study is the educational process aimed at mastering engineering graphics at a university.

The subject of the study is the pedagogical conditions for the effective development of engineering graphics by students of a construction university.

2 Methods
A pedagogical experiment in an attempt to justify the application of the proposed teaching methodology of “Engineering and Computer Graphics” for the effective development of competencies inherent in the educational program was conducted from 01.10.2018 to 31.12.2018. on the basis of the Kazan University of Architecture and Civil Engineering, in the first-year groups of the construction department. For this reason three experimental groups with a total of 30 people each were randomly allocated from the cohort. At the beginning of the experiment, cognitive testing was carried out, which showed the similarity of the experimental groups among themselves. Then each group was asked to do the same graphic work on the topic “Intersection of surfaces” (Figure 1), namely: cylinders and hemispheres whose centers are offset from each other.

![Figure 1. Construct of three views.](image)

To perform this work, you must:
1. To know the basic rules of geometric construction and the mutual intersection of plane and space models.
2. To be able to perceive the optimal ratio of parts and the whole on the basis of graphic models and represent the shape of objects and their relative position in space.
3. To knowledgeable about the methods of projection and representation of spatial forms on the plane.
4. To have skills in using drawing tools and computer graphics packages to build two and three-dimensional geometric models of the object.
During test performance, each group had to make it using different approaches: the first group needed to do the drawing manually, the second group - in AutoCAD, the third group needed to do the drawing both manually and in the AutoCAD graphics editor.

Thus, the first group did the intersection of the surface manually. When doing the work manually, the student is guided by the algorithm for solving the problem of intersecting surfaces (Figure 2).

Figure 2. Construction of the intersection line.

Note that the construction of the intersection line of the hemisphere with the cylinder was not difficult for some students, as the result of the intersection is a circle. Students of the first group mastered the basic rules of geometric construction and the mutual intersection of plane and space models.

The second group of students performed this work in the computer program AutoCAD (Figure 3). AutoCAD logic operations allow to create complex objects that represent a new, non-standard form of a 3D model as a result of the merger of several volumes. When doing this work on a computer, the procedure for solving this task is different from manual work.

This group performed the task using the logical command "Intersection". This command allows you to build 3D models in AutoCAD by isolating the volume, which is common to two or more intersecting objects located in any planes. Students tested the construction and intersection of plane and spatial models on a computer. Students also learned how to compile the necessary design documentation for the part on the computer.
The third group of students did the work manually first, then on the software AutoCAD. Knowing the algorithm for solving these two problems, they coped with this work without difficulty. Since they needed to do one job, but in different ways. Thus, they quickly got the things done.

3 Results and Discussion
All these three diagrams were checked, accepted and assessed by the teacher according to the graphic work requirements. As a result of the work performed, the students of the three groups gained different experiences. In addition, it also should be kept in mind that the time taken to complete the same work varied significantly. Namely, the first group, doing work on paper, spent approximately three hours. The second, using a computer approach, spent an average of two hours, this is due to the fact that working on a computer is not as time-consuming as manual, however, this method requires a preliminary acquaintance with the AutoCAD graphics editor, which is required an extra time for some students who have not previously been familiar with this program also. The third group, as it did double work, managed on average in four hours. However, students in the third group gained more skills.

It is also should be noted that it was easier for some students to make drawings on AutoCAD software, and for those students who possess knowledge of the art base or the basics of engineering graphics it was not difficult to suppress the surface manually.

As a result of the implementation of the proposed graphic work, students mastered the skills of working with graphic spatial objects, learned how to make drawings, prepared to the maintenance of design management that require skills from realizers, which are developed as a result of performing graphic works in the discipline "Engineering and computer graphics." Students also learned the basics of working on the AutoCAD software.

The experiment showed that the combined method of work performance gave the best result, thus, the most effective approach is to construct the part in a computer program, and then, having an idea of the design object, it is easier to cope with constructing it on a piece of paper. Thanks to this method, the student can pre-imagine the model of the part and it will be easier for him to draw it on the sheet. But there may be situations when it is more simple to work manually for the student. In this case, the choice of method is also unambiguous. Therefore, it is very important to combine traditional and computer technologies together. Computer technology will simplify some types of routine work in the classroom on descriptive geometry, as well as contribute to the realization of the creative potential of students, give them the opportunity to realize their ideas using modern technology [32].
It should be noted that in addition to AutoCAD, there are other computer technologies for studying, such as BIM-technologies, in particular Revit, as the most popular BIM program. For the further development of research aimed at obtaining pedagogical conditions for the effective development of engineering graphics, the use of other computer technologies is possible.

4 Conclusions
The experiment we examined to complete the assignment on the topic “Surface intersection”, which has a great practical value not only for making construction drawing of the elements, but also for their manufacture, showed that competent knowledge of the methods and algorithms of engineering graphics will easily allow students, future engineers and designers, to cope with the performance graphic targets both manually and on the computer. At the same time, a skill of using the AutoCAD software makes it easier to the designer to construct drawings and sections, thereby expanding the capabilities of students - future designers.

At the same time, we believe that the training on graphics of students of a technical university is very important for the full preparation of a specialist in the construction industry. Therefore, it is important to take into account the basic capabilities of first-year students, as a rule, not ready to immediately begin to study computer graphics, due to the lack of basic knowledge on the construction and design of images. For effective training of future builders, it is necessary to develop their skill in drawing on paper using traditional drawing tools. And the use of three-dimensional computer graphics in the learning process contributes to a better assimilation of basic concepts, methods, the acquisition of practical skills and abilities, the development of spatial thinking. And as a result, it improves the quality of graphic work that will be required in industry.

A study conducted on the example of studying engineering graphics by students of a construction university showed that the combined use of the AutoCAD computer program and the traditional approach to studying related to graphic work on paper gives the best result in mastering this discipline in terms of mastering the competencies required for the formation of general professional competencies future civil engineer, compared with traditional approaches, only on paper, and fully computer-based approach. However, it is not advisable to limit oneself to using only the computer environment of AutoCAD, since other environments currently exist. The choice of AutoCAD is due only to the presence of this program in the educational process and its use in the curriculum. We recommend that teachers leading the discipline "Engineering and computer graphics" take advantage of the experience gained in this study.

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