



METHODS FOR IMPROVING THE METHODOLOGY OF DEVELOPING STUDENTS' COMPETENCE THROUGH TEACHING ENGINEERING GRAPHICS

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Abstract

This research aims to improve the methodology for developing the project-technological competence of future engineers through the teaching of engineering and computer graphics. The rapid advancement of technology and the increasing complexity of engineering tasks necessitate innovative approaches to education. By integrating modern pedagogical strategies and digital tools into the curriculum, this study strives to enhance students' ability to effectively design, analyze, and implement engineering solutions. A mixed methodological approach was employed, encompassing an analysis of current teaching practices, experimental application of innovative methods, and assessment of student outcomes. The results demonstrate that the integration of computer modeling, interactive design tasks, and collaborative projects significantly enhances the project-technological competence of engineering students. These findings serve as a foundation for developing a more effective teaching methodology aimed at adapting educational practices to industry needs and technological advancements.

Keywords: Engineering graphics, Modern teaching methods, CAD programs, 3D modeling, Project-based learning, Interactive simulation, Students, Control group, Experimental group, Practical skills, Creativity, Teamwork, Innovative solutions, Teaching effectiveness, Educational technologies, Theoretical knowledge.

Introduction

In today's rapidly developing technological era, there is a growing demand for highly skilled specialists in the engineering field who can solve complex industrial



problems. One of the key competencies essential for a modern engineer is project-technological competence, which encompasses the ability to conceptualize, design, analyze, and implement technological solutions. This competence is particularly crucial in fields such as automotive engineering, construction, and mechanical engineering, where activities require precision, creativity, and advanced technological knowledge. [1]

Engineering and computer graphics are considered core subjects in developing this competency. These subjects enhance students' technological literacy by teaching them spatial visualization, technical drawing, and design principles. However, the traditional teaching methods employed in this field often fail to meet the practical needs of future engineers or do not sufficiently utilize the capabilities of modern digital tools and methodologies. As a result, many students, while possessing theoretical knowledge, lack practical skills that meet industry requirements.[2]

Integrating innovative methods into the teaching process of engineering and computer graphics, including computer-aided design (CAD) programs, 3D modeling, and interactive simulation tools, can be an effective way to address this issue. This approach serves to enhance students' ability to apply theoretical knowledge in real-life situations by making the learning process engaging and more practice-oriented. Additionally, the implementation of project-based learning and team assignments helps students acquire skills crucial for modern engineers, such as critical thinking, problem-solving, and teamwork. [3]

The purpose of this study is to develop the design and technological competencies of future engineers by improving the methodology of teaching engineering and computer graphics. Specifically, the following tasks are planned:

1. Analyze the current state of teaching engineering and computer graphics.
2. Identify the main problems faced by students and teachers.
3. Propose innovative teaching methods using digital tools and active learning strategies, and assess their effectiveness.

By achieving these objectives, the research contributes to adapting engineering education to the dynamic demands of industry and preparing students for success in a technology-driven world. [4]



Analytical Method:

Analysis of advanced foreign and domestic experiences in engineering graphics. The analytical method is crucial for improving educational processes and introducing new approaches in the scientific field. In engineering graphics, this method helps identify the most effective approaches by studying training systems and practices used in various countries. When analyzing foreign and domestic experiences, factors such as teaching methods, the overall structure of the education system, student-teacher interactions, and the level of technology utilization are taken into account.

Advanced methods of teaching engineering graphics are widespread abroad, especially in developed countries such as the USA, Europe, and Japan. In these countries, engineering graphics encompasses not only traditional drafting skills but also advanced technologies such as computer-aided design and 3D modeling. The following approaches are commonly used: [5]

Computer-Aided Design (CAD) Programs:

In foreign educational institutions, for example, in the USA and Europe, CAD programs such as AutoCAD, SolidWorks, CATIA, and Rhinoceros are widely used. These programs provide students with opportunities not only to create technical drawings but also to develop 3D models and animations. Computer-aided design enables students to produce high-precision technical drawings and projects, which enhances their practical skills.

3D modeling and visualization: In Europe and the USA, specialized programs (such as Blender and 3ds Max) are also used to teach students 3D modeling in engineering graphics classes. With these programs, students can create 3D models of real-life objects and test them in a virtual environment. This approach allows students to learn not only how to create drawings but also how they function in practice.

Project-based learning: Project-based learning is widely adopted in Europe and the USA. In this method, students learn by solving real engineering tasks. For example, during the learning process, students create 3D models, mechanical system drawings, and other graphic materials based on projects they develop themselves. This approach brings students closer to practical experience and develops their project-based problem-solving skills. [6]



Interactive simulations and virtual realistic laboratories: In some countries, such as Japan, interactive simulations and virtual laboratories are used to teach students engineering graphics and design. With these technologies, students can simulate various challenges that arise when creating projects. For instance, they can virtually test their designs by considering material properties, mechanical forces, and other factors.

In Uzbekistan and other Central Asian countries, engineering graphics education has its own distinct characteristics. Traditional teaching methods often focus on technical drawing, but in recent years, modern technologies and methodologies have been introduced. Analysis of local practices reveals the following features:

Traditional methods: In many higher education institutions of Uzbekistan, traditional drafting and technical drawing approaches are used as the primary method of teaching engineering graphics. This method teaches students skills such as creating accurate drawings, maintaining symmetry and proportions, and clearly depicting details. However, this approach is based solely on theoretical knowledge and is limited in developing students' practical skills.

Computer-aided drafting: Some universities in Uzbekistan have implemented CAD programs, such as AutoCAD and SolidWorks. However, the process of teaching these programs can often be less effective than traditional teaching methods. For the effective use of these programs, teachers themselves must learn advanced technologies and apply interactive approaches in their lessons. [7]

Development of project-based learning: Project-based teaching methodology is gradually expanding in local educational institutions. In this approach, students work in groups to solve real engineering problems. However, the widespread implementation of this method requires the necessary infrastructure and teacher training.

Simulation and laboratories: Although efforts to introduce virtual simulations and laboratories in local higher education institutions have begun, these technologies are still used to a limited extent. Some major universities in Uzbekistan are updating software and technical equipment for the implementation of simulations and virtual laboratories, but this process is still in its early stages.

Comparison between control and experimental groups using modern methods with students: The experimental methodology is widely used in scientific research to obtain real data and test theoretical approaches in practice. To study the



effectiveness of applying modern methods in teaching the subject of Engineering Graphics, the differences between the control and experimental groups of students were analyzed in the experiment. This experiment determined what improvements students can achieve by applying modern teaching methods and what differences they show compared to traditional methods.

The main goal of the experiment is to assess the effectiveness of integrating modern teaching methods - computer-aided design programs, interactive lessons, 3D modeling, and project-based learning - into the educational process. The following tasks were performed through the experiment:

1. Determining the knowledge and skills in engineering graphics of the group trained using modern methods.
2. Comparison with a group taught using traditional methods.
3. Analyze the results of both groups and determine which method is more effective.

Two groups participated in the experiment:

Control group (traditional methods): In this group, students were taught using traditional methods. This teaching approach was based solely on creating technical drawings and developing basic drafting skills. Computer-aided design programs and 3D modeling techniques were not used in this group.

Experimental group (modern methods): In this group, students learned using modern teaching methods. This group incorporated computer-aided design programs, 3D modeling, interactive simulations, and project-based learning methods.

Duration of the experiment: The experiment was conducted over two semesters. A specific curriculum was established for each group, and the educational process was organized based on this curriculum. Classes were held twice a week, with each lesson lasting 90 minutes. At the end of the experiment, the practical projects and tests completed by the students were evaluated.

The following methods were employed in the experimental group:

Computer-aided design (CAD): Students were taught to create technical drawings and design 3D models using programs such as AutoCAD and SolidWorks. By utilizing these programs, students gained the ability to create not only traditional drawings but also their virtual models, analyze changes, and test how designs function in practice. [8]



3D Modeling and Visualization: Using 3D modeling software (such as Blender or SketchUp), students were provided with the opportunity to view and test their projects in three dimensions. This allowed students to ensure the accuracy and quality of their designs.

Project-based learning: Students, divided into groups, developed practical projects to solve real engineering problems. Throughout these projects, students enhanced skills such as teamwork, planning, task allocation, and technical problem-solving.

Interactive Simulation: Simulation software enabled students to test projects under various conditions. For instance, simulations were conducted considering factors such as material strength or heat effects. [9]

At the conclusion of the experiment, the differences among students were observed as follows:

Theoretical knowledge and practical skills:

- Control group: Students taught using traditional methods demonstrated good knowledge in creating technical drawings, but encountered difficulties when using 3D modeling and modern design software.
- Experimental group: Students taught using modern methods acquired significantly higher skills in 3D modeling and the use of CAD programs. They achieved excellent results not only in creating technical drawings but also in developing practical projects.

Creativity and critical thinking:

- Control group: Although students taught by the traditional method achieved good results in drawing, they displayed limitations in creative approaches, particularly in developing projects in an innovative manner.
- Experimental group: Students who used modern methods achieved better results in approaching projects creatively, applying various technological solutions, and solving problems innovatively.

Teamwork and collaboration:

- Control group: Although students taught using traditional methods achieved good results in teamwork, they were more accustomed to individual work and showed shortcomings in collaboratively creating innovative solutions.



- Experimental group: Students taught using modern methods demonstrated significantly better performance in effective teamwork, making strategic decisions for projects, and solving team-based problems.

The results of the experiment demonstrated that modern teaching methods help students become more skilled, creative, and equipped with practical abilities. Through the use of CAD software, 3D modeling, and project-based learning approaches, students developed skills for effective practical work. Additionally, modern methods encouraged students to collaborate and generate innovative solutions. The findings of this experiment indicate the necessity of broader implementation of modern methods in the education system. [10]

Conclusion:

This study aimed to examine the effectiveness of applying modern methods in teaching engineering graphics. Throughout the research, the differences between traditional teaching methods and modern approaches, as well as the impact of each method on students' knowledge and skills, were thoroughly analyzed. Consequently, it was determined that the introduction of modern methods into the educational process offers several advantages that ensure higher results and efficiency for students.

Application of modern methods in education: Modern teaching methods employed in the experimental group, particularly computer-aided design programs such as AutoCAD and SolidWorks, along with 3D modeling and interactive simulations, effectively enabled students to acquire skills necessary for solving real engineering problems. These methods taught not only how to create technical drawings but also how projects function in practice, how to create virtual models, and how to test these models under various conditions. In this process, students became more engaged in problem-solving using innovative and creative approaches, thereby reinforcing their knowledge.

Development of students' skills: Students taught using modern methods not only acquired technical and theoretical knowledge but also significantly enhanced their practical skills. Through 3D modeling and CAD programs, students developed practical abilities by creating their own designs and simulating them. This provided students with opportunities to further refine their projects, search for optimal solutions, and pay close attention to technical details. Additionally, team-based



projects were conducted, which fostered collaboration among students, task distribution, and the development of creative approaches to problem-solving.

Limitations of traditional methods: While students in the control group taught using traditional methods achieved good results in creating technical drawings, they encountered difficulties in utilizing modern design and modeling technologies. The limitations of traditional methods were confined to teaching students only drafting skills, which reduced their effectiveness in solving real-world creative and practical tasks. Furthermore, students faced challenges in learning new technologies, which hindered their ability to update and improve their knowledge.

Teamwork and critical thinking: Modern methods have further developed teamwork among students. Through project-based learning and interactive simulations, students gained extensive experience in collaborating, developing new solutions, and considering each other's ideas. These methods were particularly effective in fostering creativity and critical thinking skills. In the control group, however, some difficulties were observed in teamwork, as traditional methods tended to focus students more on individual work.

The impact of innovative approaches on education: Modern methods have developed not only students' technical skills but also their innovative thinking. With the help of simulations and 3D models, students have gained more confidence in testing their projects and implementing changes. This, in turn, has helped them further improve projects, find optimal solutions, and better understand the practical application of each design. The results of this study show that modern teaching methods are quite effective in developing students' knowledge and skills in engineering graphics. While traditional methods are limited only to creating technical drawings, modern methods allow students to combine technical, creative, and practical skills. These methods teach students not only to create drawings but also how they work in practice, how to develop optimal designs, and how to work in teams. Thus, the wider application of modern teaching methods in engineering graphics education helps to prepare students as highly qualified specialists.

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