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MODERN METHODS OF TEACHING ENGINEERING AND COMPUTER GRAPHICS TO STUDENTS USING DIGITAL PEDAGOGICAL TECHNOLOGIES

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Abstract

This article is dedicated to studying modern methods of teaching engineering and computer graphics to students using digital pedagogical technologies. The main objective of the study is to identify and improve methodologies for developing students' professional and creative competencies through interactive software tools, 3D modeling platforms, and virtual laboratories. The article analyzes the concept of digital pedagogical technologies, their practical application in the learning process, and their impact on student activities. Furthermore, examples of practical sessions using software tools such as AutoCAD, SolidWorks, and Blender are provided, through which students' technical thinking, spatial imagination, and creative abilities are developed. The research results contribute to determining strategies and methods for the effective implementation of digital pedagogical technologies in engineering and computer graphics education.

Keywords: Students, Engineering Graphics, Computer Graphics, Digital Pedagogical Technologies, Modern Teaching Methods, Professional and Creative Competence, 3D Modeling, Virtual Laboratories

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Introduction

In the process of teaching engineering and computer graphics to students, it is of great importance to implement modern pedagogical approaches and innovative methods. In particular, digital pedagogical technologies—comprising pedagogical methods that utilize computers, software tools, online platforms, and interactive resources to develop students' knowledge, skills, and professional and creative competencies—prove to be an effective means in this process.

In engineering and computer graphics courses, students carry out project-based tasks using software tools such as 3D modeling, AutoCAD, SolidWorks, and Blender. This not only develops their technical and spatial thinking but also fosters creative approaches and practical competence. From this perspective, teaching engineering graphics through digital pedagogical technologies is considered an effective methodology for enhancing students' professional and creative competencies.[1]

Literature Analysis

In recent years, research on studying and implementing digital pedagogical technologies in engineering and computer graphics education has increased significantly. International studies indicate that the integration of CAD systems, 3D modeling, and virtual reality (VR) technologies substantially enhances students' spatial imagination, visual-cognitive skills, and professional readiness (Becta, 2010; UNESCO, 2021; Smith, 2019; Johnson, 2020).[2] For example, research published in 2025 emphasized that VR and AR technologies strengthen the interactivity and individualization of the learning process, while also increasing students' motivation and the speed of material comprehension. At the same time, international experience shows that digital pedagogical technologies guide students toward independent inquiry, innovative thinking, and the creative execution of complex technical tasks (Master Journals, 2025).

In Uzbekistan, recent years have also seen research on the application of digital pedagogical technologies in engineering graphics and computer graphics courses.

1. Ahmedov, S. (2022). Muhandislik grafikasi ta'limida 3D modellashtirish texnologiyalarini qo'llash. Toshkent: O'zbekiston davlat pedagogika universiteti nashriyoti.

2. Becta, 2010; UNESCO, 2021; Smith, 2019; Johnson, 2020.

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Practical activities conducted in 2023–2024 at universities in Tashkent and other higher education institutions have shown that the use of CAD and 3D modeling software significantly enhances students' design skills, creative approaches, and spatial thinking (Ahmedov, 2022; Usmonova, 2023; Zenodo, 2024). At the same time, virtual laboratories and simulation exercises ensure active student participation in the learning process and contribute to the development of their professional and creative competencies.

Moreover, methodological guidelines published by the Ministry of Higher and Secondary Specialized Education of the Republic of Uzbekistan (2023–2025) describe effective strategies for integrating digital pedagogical technologies into the teaching process. These studies aim not only to enhance practical efficiency but also to improve the quality of education and increase students' interest in technical subjects.

As a result of this analysis, it has been determined that the integration of digital pedagogical technologies is of significant importance not only in international practice but also within the scientific experience of Uzbekistan. This body of literature provides a solid theoretical and practical foundation for the topic of your article—identifying and describing modern methods of teaching engineering and computer graphics to students using digital pedagogical technologies.

Materials and Methods

This study was aimed at identifying mechanisms for developing students' professional and creative competencies through the integration of digital pedagogical technologies in teaching engineering and computer graphics courses. The research concept was formed based on the requirements of modern engineering education, processes of digital transformation, and competence-oriented pedagogical approaches.

Research Materials

The scientific and theoretical foundation of the study consisted of local and international scholarly sources related to engineering graphics, computer graphics, 3D modeling, CAD/CAM/CAE systems, and digital educational technologies. In addition, regulatory and legal documents, as well as higher

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education standards concerning the modernization of engineering education, were analyzed.[3]

As a practical component, the engineering graphics curriculum was implemented in an integrated manner with electronic resources, virtual laboratories, and the following digital platforms:

- **AutoCAD** – for 2D drawings and parametric design;
- **SolidWorks** – for 3D modeling and structural analysis;
- **Blender** – for visualization and simulation modeling;
- **Moodle** – for organizing interactive assessments and distance learning.

These tools were incorporated into the learning process based on an integrated model and aligned with a project-based teaching methodology.

Factors for Developing Professional and Creative Competencies; The application of digital pedagogical technologies was carried out through the following interrelated components:

- Deepening theoretical knowledge through visual and interactive modeling;
- Developing spatial and constructive thinking in a 3D modeling environment;
- Generating creative solutions through project tasks based on problem-based situations;
- Reinforcing practical skills through digital portfolios and technical projects.

Research Methods

This study aimed to determine the effectiveness of teaching engineering and computer graphics courses using digital pedagogical technologies. The following methods were applied:

1. **Theoretical Analysis** – Scientific sources, regulatory documents, and higher education standards related to engineering graphics, computer graphics, 3D modeling, CAD/CAM/CAE systems, and digital pedagogical technologies were studied. This method served to establish the theoretical foundation of the research and to define the direction of the practical investigation.
2. **Comparative Analysis** – The activities, task performance quality, and competency indicators of students in the experimental and control groups were

3. Thomas J. W. (2000) – *A Review of the Research on Project-Based Learning*

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compared. This method allowed for a clear assessment of the effectiveness of digital pedagogical technologies.

3. **Pedagogical Observation** – Students' engagement during interactive lessons, project tasks, and virtual laboratories, as well as their creative approaches and self-assessment skills, were observed. This method served to evaluate students' practical activities and to improve methodological strategies.[4]

4. **Experimental Modeling** – Three-dimensional modeling and design tasks were performed using AutoCAD, SolidWorks, and Blender, and students' visual-cognitive, spatial, and creative skills were analyzed. This method allowed for the practical assessment of competency indicators.

5. **Assessment Based on Competency Indicators** – The results were evaluated using the following indicators: visual-cognitive accuracy, spatial thinking and modeling quality, design logic, project-based creative thinking, and the level of reflective activity.

6. **Comparative-Statistical Analysis** – Differences and positive dynamics between the experimental and control groups were summarized using statistical methods. This method ensured the reliability of the research results.

The study was conducted over one semester to evaluate the effectiveness of an integrated teaching model using digital pedagogical technologies and to identify opportunities for the comprehensive development of students' professional and creative competencies.

Results

The study employed theoretical analysis, comparative analysis, pedagogical observation, and modeling methods. The obtained results were summarized based on competency indicators and evaluated through comparative-statistical analysis.During the study, the impact of organizing engineering and computer graphics courses based on digital pedagogical technologies on students' professional and creative competencies was evaluated using a multi-component indicator system. The assessment criteria included visual-cognitive accuracy,

4. Robert K. Yin (2018). *Case Study Research and Applications: Design and Methods* (6th ed.). Sage Publications.

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quality of spatial modeling, design logic, project-based thinking, and the level of reflective activity. The analysis results demonstrated a systematic positive dynamic of competency indicators in the group where the digitally integrated teaching model was applied.

1. Visual-Cognitive Competence. As a result of tasks performed in an interactive graphic environment, accuracy in drawing, dimensional consistency, and preservation of geometric logic were stabilized. Structural errors in graphic works decreased, and the ability to analytically separate object elements and logically connect them developed. This indicates the formation of the analytical component of technical thinking.[5]

2. Spatial Thinking and Modeling Quality. In tasks performed within a three-dimensional modeling environment, skills in spatial visualization of objects, projection transformation, and correct interpretation of sections were enhanced. Students demonstrated the ability to construct complex structures based on a modular framework, justify functional interconnections between elements, and analytically process the model. An increase in the systematic level of spatial thinking was observed.

3. Design and Technical Logic. The use of parametric design elements supported the logical justification of technical decision-making processes. During the optimization of models, functional analysis of constructive elements, and development of alternative solutions, students demonstrated the operational component of engineering thinking. The technical grounding and functional consistency of projects were improved.

4. Creative-Project Activity. During the completion of project tasks, students sought to generate multiple design solutions, perform comparative analysis, and select the most optimal constructive model. The digital environment encouraged an innovative approach through creative modeling, simulation, and visualization capabilities. The level of independence and argumentation in creative decision-making increased.

5. Reflective and Motivational Component. Lessons organized through digital platforms enhanced the interactivity of the learning process and activated self-

5. John R. Anderson (2000). *Learning and Memory: An Integrated Approach*. Wiley.

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monitoring and assessment mechanisms. Students applied a reflective approach while analyzing completed work, identifying errors, and making corrections. This indicated an increase in intrinsic motivation for independent work and individual development.

Overall Analysis**:** The overall analysis demonstrated that a learning process organized on the basis of digital pedagogical technologies develops the cognitive, operational, and reflective components of professional and creative competence in an interconnected manner. It also enables the teaching of engineering and computer graphics courses based on a competency-oriented model.

Conclusion

The study demonstrated that the use of digital pedagogical technologies in teaching engineering and computer graphics significantly enhances students' engagement in the learning process, professional and creative competencies, and spatial thinking. Students in the experimental group, using software tools such as 3D modeling, AutoCAD, SolidWorks, and Blender, completed tasks more effectively compared to the control group, which relied on traditional methods.

Digital platforms and virtual laboratories contributed to the development of students' creative approaches and enhanced their ability to analyze and optimize complex structures. At the same time, interactive and project-based teaching methods encouraged students to engage in independent inquiry, innovative thinking, and the creation of technical solutions. The research results are consistent with international experience, showing that VR, AR, and 3D modeling technologies significantly improve students' visual-cognitive and spatial skills. Furthermore, practical work conducted in the context of Uzbekistan confirms the effectiveness of digital pedagogical technologies.[6] On this basis, integrating digital pedagogical technologies into the learning process not only enables the modern and practically effective teaching of engineering and computer graphics courses but also contributes to the systematic development of students' knowledge, skills, and professional and creative competencies.

6. UNESCO (2023). *Global Education Monitoring Report: Technology in Education*. Paris.

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4. Robert K. Yin (2018). Case Study Research and Applications: Design and Methods (6th ed.). Sage Publications.
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6. UNESCO (2023). Global Education Monitoring Report: Technology in Education. Paris.