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TEACHING METHODOLOGY BASED ON THE INTEGRATION OF DESCRIPTIVE GEOMETRY AND COMPUTER GRAPHICS COURSES

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Abstract:
This article presents a methodology for teaching descriptive geometry and computer graphics in an integrated manner, aimed at developing students' spatial thinking, graphical reasoning, and skills in working within CAD environments. The study was conducted within the hydraulic engineering program at Andijan State Technical Institute, where the effectiveness of teaching through 3D modeling, theoretical-geometric analysis, and interactive visual environments was evaluated experimentally. The results of the experiment confirmed the high efficiency of the integrated methodology and scientifically substantiated the need to implement digital approaches in technical education.

Keywords: Descriptive geometry, computer graphics, CAD, spatial thinking, AutoCAD, SolidWorks, Revit, 3D Kompas, integrated methodology, technical education, graphical reasoning, modeling, interactive teaching.

Introduction

In parallel with modern technological advancements, the educational system—particularly in technical disciplines—requires a profound modernization, including the renewal of pedagogical approaches. A prominent issue arises from the didactic misalignment and insufficient practical correlation between the subjects of Descriptive Geometry and Computer Graphics, which hinders the effective training of technical specialists. Traditionally, Descriptive Geometry is taught in a classical manner—constructing geometric figures on paper, drawing projections, sections, and views—which does not yield optimal results for students operating in digital environments. Conversely, Computer Graphics primarily focuses on developing skills in software environments such as AutoCAD, SolidWorks, Revit, and 3D Kompas, yet students often lack a full understanding of the mathematical foundations underlying drawings, projections, and spatial relationships. As a result, one subject remains theoretical while the other is practical, taught in isolation without a coherent integration, thereby impeding the formation of engineering thinking. This disconnect becomes especially evident when students engage in practical tasks involving design, modeling, and spatial reasoning. An integrated educational approach offers a critical advantage by reinforcing interdisciplinary links and transforming theoretical knowledge into practical competence. Therefore, this paper proposes a methodology for teaching Descriptive Geometry and Computer Graphics in an integrated format within technical education, aiming to enhance students' spatial reasoning, engineering imagination, graphical literacy, and design capabilities through the use of modern software. This approach enables students to simultaneously construct geometric projections and model them within

CAD systems designed for real-world application, thus deepening their comprehension of theoretical principles through hands-on visualization. International studies corroborate the efficacy of such integration, demonstrating significant improvements in students' spatial modeling and graphical reasoning skills. For instance, experimental implementations in the United States and Germany revealed that teaching geometry fundamentals via CAD tools led to a 40% improvement in student performance. While similar efforts have commenced in Uzbekistan, a fully developed methodological framework remains absent. Integrating these disciplines allows educators to bridge theory and interactive practice, increasing engagement, fostering independent learning, and advancing technical thought. Within this context, the study develops an integrated instructional module and evaluates its effectiveness through experimental trials. Students utilize CAD software to construct geometric figures, visualize projections, generate 3D models from sections and views, and present the results in graphical form. This method cultivates not only spatial but also technological and practical thinking. Furthermore, the article explores the instructional impact of the integrated methodology, provides methodological recommendations for educators, and discusses ways to enhance lessons through interactive tools. Ultimately, a modern, efficient, visual, and interactive teaching system is established, facilitating the modernization of technical curricula, the adoption of advanced pedagogical technologies, and the elevation of student preparedness in digital learning environments.

Methodology

The present study aims to develop the didactic, methodological, and technological foundations of integrating Descriptive Geometry and Computer Graphics courses and to implement them within real educational settings to enhance pedagogical effectiveness in modern technical education. An experimental research model based on practical application was selected as the methodological approach, conducted within the Department of Architecture and Hydraulic Engineering at Andijan State Technical Institute, specifically targeting first-year students (Group K-66-24, Daytime Program) in the Hydraulic and Geotechnical Engineering program [AIQI], academic year 2024. A total of 14 students (12 male and 2 female) participated as a single experimental group. Throughout the course, key topics of Descriptive Geometry—such as projections, views, sections, epures, and surfaces—were taught using CAD platforms including AutoCAD, SolidWorks, Revit, and 3D Kompas. In this integrated approach, students initially acquired theoretical concepts, which were subsequently reinforced through 3D modeling in the computer graphics environment [1][2]. Each topic was supplemented with interactive tasks, guided instructions, and individual graphical assignments. For example, in the topic "epure construction," students first drew frontal and horizontal projections on paper, then modeled these shapes in 3D Kompas, discovering spatial relationships interactively. Every student received individual instruction on the interface, command panels, and 3D editors of CAD software, and their assignments were evaluated to assess their graphical reasoning and spatial imagination. Theoretical foundations were drawn from Murodov, Hakimov, and Kholmurzayev's "Descriptive Geometry" textbook [1], while the methodology for working in CAD environments was based on Qodirov's "Fundamentals of Computer Graphics" [2].

Additionally, the interdisciplinary integration strategies developed by Karimov [3], as well as mechanisms for applying technological tools in the learning process and methods for activating student engagement, were analyzed. Practical sessions incorporated Autodesk AutoCAD [4] and SolidWorks user manuals for creating drawings in digital editors, building 3D models, and defining surfaces and edges. The methodology combined constructivist and interactive approaches, allowing students to internalize new knowledge through experience and to apply it in completing graphical assignments by understanding the link between drawings and models [5][6]. At the end of the instruction, each student was assessed based on final test results and diagnostic tasks. Individual interviews and short written surveys revealed that students found the CAD-based classes significantly increased their understanding of Descriptive Geometry in relation to real-world design, enhanced their interest in the subject, and improved their learning outcomes [7]. Statistical analysis conducted using SPSS 26.0 confirmed the pedagogical effectiveness of integrating Descriptive Geometry and Computer Graphics through empirical evidence. Overall, the proposed methodology has been proven to yield high results in deepening theoretical foundations via practical graphical tools, implementing modern CAD software in the teaching process, and fostering spatial reasoning and design competencies within technical education.

Results and discussion

The research was conducted using an experimental methodological approach based on the integration of Descriptive Geometry and Computer Graphics subjects, and the effectiveness of the teaching was evaluated through various parameters. These included the level of mastery, spatial thinking skills, graphical reasoning, the accuracy in completing practical assignments, and indicators of creative approach, all of which were selected as the main evaluation criteria. The participants in the experiment were 14 first-year students from Group K-66-24 (AIQI) of the Hydraulics and Geotechnical Engineering program at Andijan State Technical Institute. They formed a single experimental group for the study. At the beginning of the research, an entry-level test was administered to assess the students' theoretical knowledge and their understanding of basic graphic concepts, with an average result of 61 percent. This initial indicator was marked as the baseline for monitoring changes throughout the experiment. During the course, practical assignments were given after each topic, and their performance was evaluated. Throughout the lessons, students used CAD programs (AutoCAD, SolidWorks, Revit, 3D Kompas) to create geometric shapes, construct projections, generate sections, perform 3D modeling, and identify surfaces. Through these tasks, they successfully transformed theoretical concepts of Descriptive Geometry into practical skills. From a pedagogical perspective, this approach played a crucial role in deepening students' knowledge, stabilizing the learning process, and enhancing creative thinking.

Table 1. Students mastery indicators (experiment before and next status)

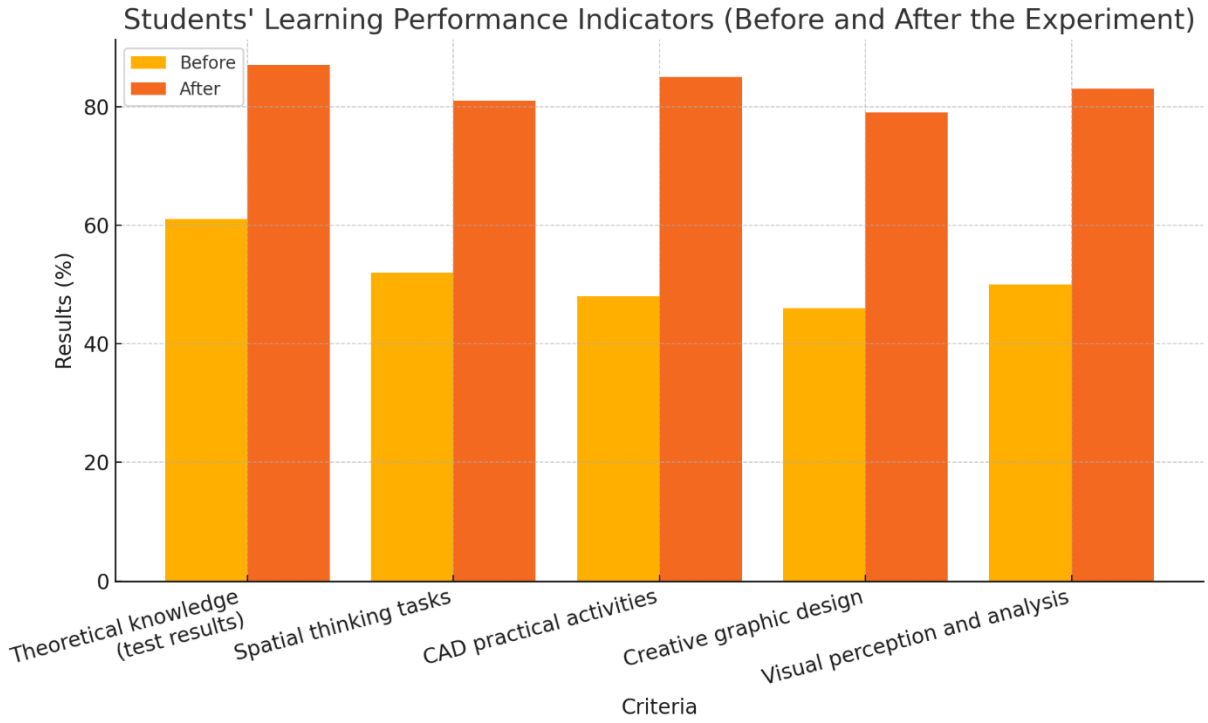
Evaluation criteria	From the experiment before (%)	From the experiment after (%)
Theoretical knowledge (test result)	61	87
Spatial thinking tasks	52	81
CAD practical training	48	85
Creative graphic design	46	79
Visual perception and analysis	50	83

From the table above, it is evident that all evaluation criteria showed a positive increase in students' knowledge. In particular, the level of mastery in practical training using CAD tools increased from 48% to 85%, while theoretical knowledge improved from 61% to 87%. Regarding indicators of graphical thinking, although students initially struggled with projecting figures in 3D format, by the end of the experiment they had reached a level where they could independently analyze the relationship between 3D models and two-dimensional drawings. To assess visual perception and spatial imagination, special graphical tasks were conducted (e.g., depicting an object in three types of projections, reconstructing a 3D model based on projections, and drawing intermediate shapes based on a given section). In these tasks, students were able to find correct solutions with more than 80% accuracy.

Statistical analysis was carried out using the T-test in SPSS 26.0 software, and the results indicated a statistically significant difference at the $p < 0.05$ level, thus scientifically validating the pedagogical effectiveness of the methodology. The results of the student questionnaires also served as important methodological evidence: students noted that learning Descriptive Geometry within the CAD environment increased their interest in the subject, brought them closer to real-world design, and helped them apply theoretical knowledge in practice.

From the teacher's perspective, the integrated methodology enabled the organization of visually interactive lessons, the active use of technological tools in communication with students, and the application of a project-based teaching approach. At the end of the experiment, students were assessed on their mastery level, graphical reasoning, and modeling skills using a three-level rating system: 9 students (64%) were categorized as "high," 4 students (29%) as "intermediate," and 1 student (7%) as "beginner."

The findings of the study demonstrate that integrating Descriptive Geometry and Computer Graphics not only deepens students' understanding of geometric concepts but also prepares them to work effectively in real engineering environments. These students become knowledgeable in CAD technologies, develop creativity, and acquire the ability to think technologically. The results indicate that this methodology has significant potential for broad implementation in technical education systems.



1- Diagram

Conclusion and suggestions

The theoretical analysis, experimental training sessions, statistical evaluation, student feedback, and review of advanced literature conducted during the study have scientifically demonstrated that the integrated teaching of Descriptive Geometry and Computer Graphics is a key factor in enhancing pedagogical effectiveness within technical education. The implementation of CAD software into the learning process has enabled students to visualize, analyze, transform, and apply traditional geometric concepts within modern digital environments. The significant improvement in students' performance—such as the increase in theoretical knowledge from 61% to 87%, spatial thinking from 52% to 81%, and CAD-related skills from 48% to 85%—confirms the effectiveness of the proposed methodology and its applicability in technical education. This approach transcends purely theoretical instruction by aligning it with real engineering practices, thereby broadening students' creative thinking, decision-making abilities, and both aesthetic and technological reasoning. Students, while studying projections, views, and sections through Descriptive Geometry, are also able to bring these concepts into tangible form through 3D modeling, fostering conscious learning and the application of acquired knowledge to novel problem-solving contexts. In this process, the instructor transitions from a provider of knowledge to an interactive facilitator who guides activities, encourages multi-perspective analysis, and supports initiative. Through integrated teaching, students developed engineering thinking, enhanced graphical reasoning, gained proficiency in CAD environments, and acquired competencies in solving complex geometric problems, graphical expression, and technological design. The high performance outcomes of the experiment, the positive student feedback, and the qualitative improvements in teaching effectiveness highlight the necessity of implementing this approach across all higher education

institutions in technical fields. Based on these findings, several scientifically grounded recommendations can be made: (1) the development of unified teaching and methodological frameworks for integrating Descriptive Geometry and CAD systems in technical institutions; (2) prioritizing CAD proficiency in the training of pedagogical personnel at the university level; (3) reinforcing the theoretical underpinnings of CAD tasks within Descriptive Geometry classes to ensure coherence between theory and practice; (4) promoting digital learning tools, virtual labs, interactive textbooks, and visual content that support interdisciplinary integration; (5) organizing the learning process based on project-based education technologies, encouraging both individual and collaborative student projects to bridge theoretical content with real-world technological processes; (6) strengthening student competencies through competitions in graphical design and CAD modeling seminars or webinars; and (7) continuously refining the methodology through evaluative analysis and developing adaptable learning modules based on student outcomes to improve instructional quality. Moreover, this methodology should be regarded as a strategic mechanism for driving digital transformation in Uzbekistan's educational system, as it not only fosters interdisciplinary integration but also shapes students into active, self-directed learners. Most importantly, it harmonizes the roles of the student as a creator, designer, and engineer, offering a practical path toward developing modern professionals with technological vision. Overall, the integrated teaching methodology developed through this study offers an innovative approach in the field of technical education, modernizes Descriptive Geometry through CAD tools, and elevates graphical literacy to a new level.

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