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THE ROLE AND PRACTICAL SIGNIFICANCE OF PROJECTION DRAWINGS, VIEWS, PERSPECTIVE ILLUSTRATIONS, AND AXONOMETRIC PROJECTIONS IN DEVELOPING STUDENTS' SPATIAL THINKING

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ABSTRACT

This article examines the role and practical significance of projection drawings, views, perspective illustrations, and axonometric projections in the development of students' spatial thinking. Spatial visualization—the ability to perceive and analyze three-dimensional objects through two-dimensional representations—is a core skill in engineering graphics education and is essential for successfully performing complex graphical tasks.

Research indicates that knowledge of projection drawings and different views enhances students' spatial thinking and improves their graphic literacy by enabling them to analyze objects across various planes. Perspective illustrations and axonometric projections—methods that represent complex forms in a single visible view—allow students to comprehend three-dimensional structures within one graphical representation. The study also analyzes the effectiveness of integrating these methods into the educational process, including through CAD and 3D modeling tools, to enhance students' spatial visualization skills. These approaches not only modernize graphic education but also strengthen students' visual-cognitive problem-solving abilities.

Keywords: Spatial thinking, projection drawing, views, perspective illustrations, axonometric projections, graphic literacy, engineering graphics, projection education.

INTRODUCTION

Engineering graphics education is a core discipline that develops the skills to accurately represent and interpret three-dimensional objects through two-dimensional drawings in technical practice. Within this field, students' spatial visualization—the ability to mentally imagine and analyze three-dimensional structures—is considered one of the most critical cognitive components, as it is essential for solving complex graphical tasks. Research indicates that knowledge of projection drawing and various views contributes to strengthening spatial visualization skills and enhances students' graphic literacy.

Drawing orthogonal and axonometric views through projection techniques, as well as representing complex forms using perspective illustrations, helps students comprehend spatial structures across different planes. Furthermore, recent pedagogical studies have noted that integrating projections, axonometric views, and drawings into the educational process significantly enhances students' spatial visualization, analytical thinking skills, and the ability to develop visual-cognitive solutions. These aspects indicate that engineering graphics education requires methodological approaches aimed not only at teaching traditional drawing skills but also at developing fundamental cognitive abilities in spatial visualization. At the same time, organizing projection drawing exercises using CAD, 3D modeling, and other digital tools further strengthens students' professional preparation.

Based on these concepts, this article analyzes the role and practical significance of projection drawings, views, perspective illustrations, and axonometric projections in developing students' spatial thinking and highlights pedagogically effective approaches.

LITERATURE ANALYSIS

Recent research has shown that methods for teaching spatial visualization and projection drawing play a significant role in developing students' graphic literacy, analytical thinking, and creative problem-solving abilities. For example, a study published in 2025 reported that teaching projection drawing using modern pedagogical technologies—such as interactive methods and digital visualization tools—significantly enhances students' spatial reasoning and mathematical thinking. This approach contributes to a better understanding of complex spatial relationships and improves students' skills in accurately executing drawings.

Using graphic software such as Blender also strengthens students' spatial visualization and simplifies the practical execution of orthogonal and axonometric views, thereby increasing the effectiveness of projection drawing exercises. Furthermore, integrating digital transformations—such as CAD, 3D modeling, and virtual reality (VR) technologies—into the drawing curriculum further enhances spatial thinking, visual-cognitive skills, and professional preparation. These pedagogical approaches contribute to improving the quality of innovative teaching in higher education.

Interactive pedagogical approaches for developing students' spatial thinking have also been highlighted in recent studies. For example, a study published in 2025 recommended using pedagogical technologies to teach axonometric views as a means to increase students' engagement in drawing activities. International researchers have also provided valuable insights: the application of Augmented Reality (AR) technology in engineering graphics courses has been found to effectively improve students' spatial skills and academic performance, thereby reinforcing the role of digital interactive approaches in enhancing spatial visualization.

The literature indicates that integrated methodologies—namely, pedagogical approaches combining descriptive geometry, projection drawing, and axonometric projections—are effective in deeply developing students' spatial thinking. For instance, a study published in 2025 noted that integrating descriptive geometry and drawing positively reinforced spatial reasoning. Overall, the analysis of scholarly literature shows that in teaching projection drawing, views, perspective illustrations, and axonometric projections, the use of modern pedagogical technologies (interactive methods, AR/VR, CAD/3D modeling), the integration of digital tools, and the application of integrated methodologies play a significant role in strengthening students' spatial thinking and visual-cognitive skills.

MATERIALS AND METHODS

This section provides a detailed description of the materials and methods used in the study on the role and practical significance of projection drawings, views, perspective illustrations, and axonometric projections in developing students' spatial thinking. The study was based on an analysis of local and international literature, educational standards, and digital pedagogical technologies published between 2020 and 2026. The aim of the research was to identify the factors that contribute to the development of students' spatial thinking and professional competencies in the teaching of engineering and computer graphics.

RESEARCH MATERIALS

1. Scholarly Literature:

- International and local scientific articles: studies on enhancing visual skills through spatial visualization and projection methods. For example, analytical articles exist on using modular approaches to methodically develop spatial thinking.
- Graphic and drawing methodologies: methodological studies on performing orthogonal and axonometric projections using Blender and AutoCAD.
- Studies on digital tool integration: research emphasizes that technologies such as CAD/3D modeling and VR are effective in further strengthening students' spatial visualization.

2. Regulatory and Legal Documents:

- Normative documents on the higher education system of the Republic of Uzbekistan, educational standards, and graphic subjects provided the legal and structural basis for the study.

3. Educational and Digital Resources:

- Curricula for engineering and computer graphics, CAD/CAM/CAE platforms such as Blender, AutoCAD, SolidWorks, Fusion 360, as well as distance learning platforms (Moodle, Google Classroom), were used as research materials.

Factors for Developing Professional and Creative: In this study, the development of students' spatial thinking and competencies was carried out through the following factors:

1. Strengthening Theoretical Foundations: Mastery of in-depth theoretical knowledge in projection drawing, views, perspective illustrations, and descriptive geometry, as well as understanding design principles and interactive teaching methods (problem-based tasks, project-based learning).

2. Developing Creative and Spatial Thinking: Assignments focused on modeling complex 3D forms, performing critical analyses, and producing creative solutions.

3. Information, Communication, and Digital Technologies: Engaging with CAD/CAM/CAE software, creating virtual laboratories and digital portfolios, and applying blended and distance learning methods.

4. Developing Practical Skills: Creating 2D and 3D drawings, modeling and visualizing engineering objects, testing real-world problems, and developing proficiency in modern graphic software.

Research Methods:

The following scientific and pedagogical methods were successfully applied during the research process:

- **Theoretical Analysis** — examining local and international scientific sources related to the teaching of engineering and computer graphics, identifying key concepts and methods, and establishing the theoretical foundations.
- **Comparative Analysis** — comparing pedagogical practices in projection and digital approaches across various higher education institutions.
- **Pedagogical Observation** — analyzing students' spatial visualization abilities and creative activity during practical and laboratory sessions.
- **Modeling** — developing a methodological model aimed at enhancing students' spatial thinking and measuring its effectiveness.

The use of these research materials and methods—based on modern digital tools, digital pedagogical technologies, and advanced theoretical approaches—contributed to the creation of a methodological system with solid scientific foundations for developing students' spatial thinking, visual-cognitive skills, and professional competencies.

RESULTS

This study focused on determining the role and practical significance of projection drawing, views, perspective illustrations, and axonometric projections in developing students' spatial thinking. Based on the research findings, the following key conclusions were drawn:

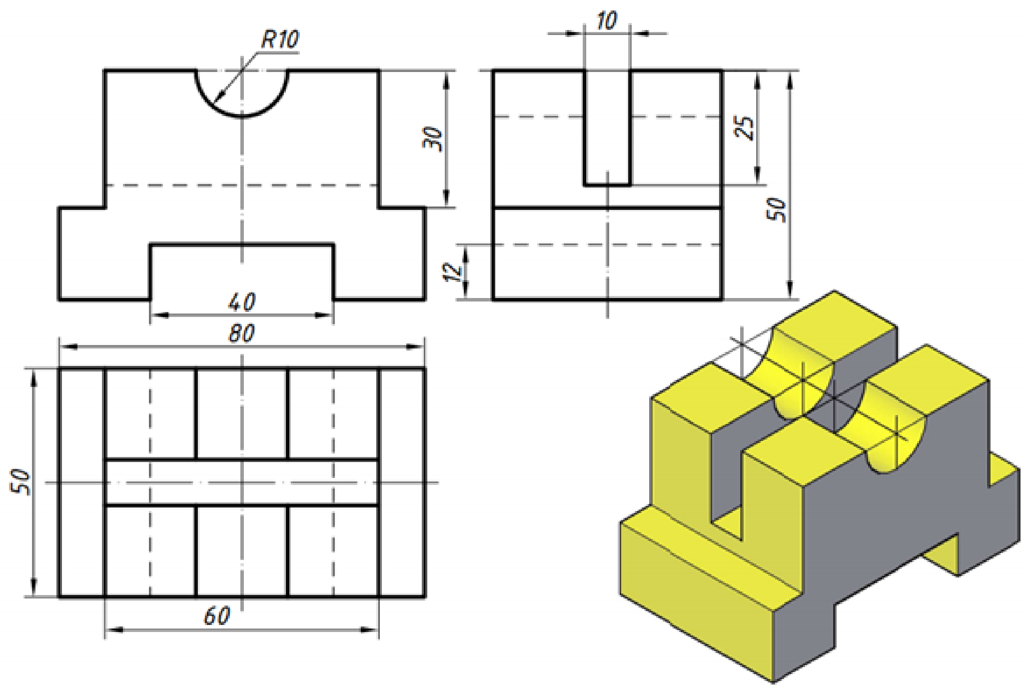
1. Complexity and Multifaceted Nature of Developing Spatial Thinking and Competencies: The study revealed that the development of students' spatial thinking and professional competencies is a complex process that involves not only theoretical knowledge and practical exercises but also the integration of interactive and digital pedagogical tools. In particular, drawing orthogonal and axonometric views using Blender, AutoCAD, or other graphic software significantly strengthens students' spatial visualization skills.

2. Effectiveness of Integrating Digital Technologies: The use of digital tools such as online courses, virtual laboratories, CAD/CAM/CAE systems, and electronic portfolios improves students' ICT skills. These technologies enable students to learn independently, acquire knowledge through hands-on experience, and enhance their ability to solve complex graphic tasks, thereby increasing the effectiveness of modern teaching. This finding is also supported by recent studies, which emphasize that digital technologies play a crucial role in strengthening spatial thinking and visual-cognitive skills.

3. **Creative Thinking and the Effect of Creative Tasks:** Project-based activities, modeling of complex technical objects, and assignments aimed at critical analysis contribute to the development of students' creative abilities. Additionally, generating creative solutions using graphic software allows students to develop new technical ideas, thereby enhancing their overall creative potential.

4. Approaches to 21st Century Competencies: The study revealed that the development of spatial thinking and graphic skills is not limited to technical knowledge alone; it also fosters 21st-century competencies such as adaptability, digital literacy, teamwork, and problem-solving. The application of modern pedagogical approaches and digital tools effectively supports the formation of these competencies.

5. Results of Integrated Teaching: Overall, the research methodology demonstrated that integrating projection drawing, axonometric views, and modern technologies significantly contributes to the development of students' spatial thinking. Specifically, the integrated teaching approach markedly improves students' graphic knowledge and their ability to work independently.
During the study, step-by-step modeling tasks were designed based on orthogonal views, sections, and axonometric projections to develop students' spatial thinking. This approach facilitated a systematic transition from 2D drawings to 3D models. Figure 1 illustrates the process by which students construct an axonometric representation of an object based on orthogonal projections (front, top, and side views), sections, and cross-sections, and subsequently create a spatial model in a 3Dmodeling environment using CAD software.



1-Figure: Projection drawing, views, axonometric projections.

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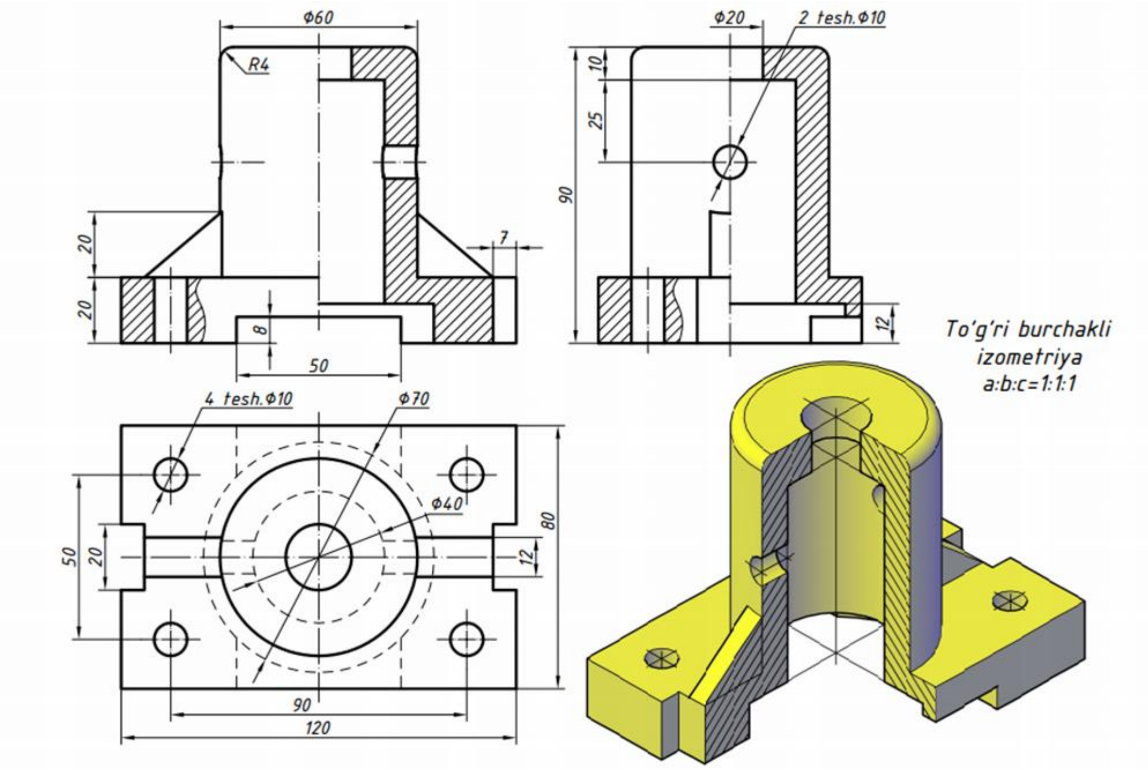

2-Figure: Rectangular isometry. Sections.

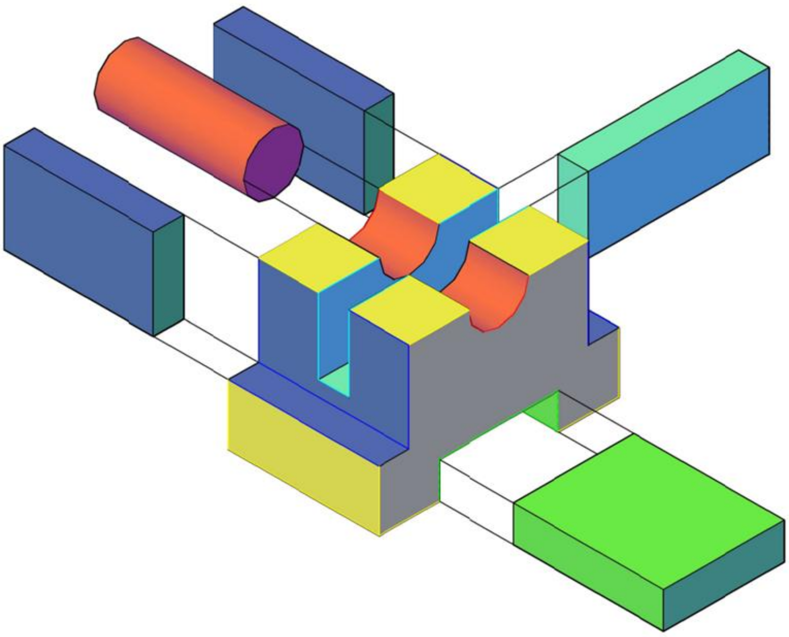

Figure 1. Spatial modeling of an object based on orthogonal views, section, and axonometric representation

The step-by-step transition process illustrated in the figure was observed to develop the following skills in students:

- analyzing a three-dimensional object on two-dimensional planes;
- understanding the internal structure through sectional views;
- visualizing spatial integrity in axonometric projection;
- finalizing the graphical solution through 3D modeling.

The results of the pedagogical observations demonstrated that integrating orthogonal and axonometric representations enhanced students' visual-cognitive activity and significantly strengthened their analytical thinking during the completion of complex graphical tasks. In particular, the transition from a 2D drawing to a 3D model served as an effective factor in developing spatial transformation skills. Thus, the integration of projection drawing, sectional views, and axonometric representations with modern CAD tools has been confirmed as a methodologically effective approach to developing students' spatial thinking.

CONCLUSION

The present study demonstrated that projection drawing, orthogonal views, sections and cross-sections, pictorial representations, and axonometric projections possess significant pedagogical value in developing students' spatial thinking. As a central cognitive component of engineering graphics, spatial thinking enables students to mentally visualize three-dimensional objects, analyze them on two-dimensional planes, and perform 2D–3D transformations.

The research findings confirmed that step-by-step analysis of an object based on orthogonal projections, understanding its internal structure through sections and cross-sections, and representing spatial integrity in axonometric projection significantly enhance students' visual-cognitive activity. In particular, the transition from a 2D drawing to a 3D model serves as an effective methodological tool for developing spatial transformation skills. Moreover, the integration of CAD/CAM/CAE systems, 3D modeling platforms, and digital pedagogical technologies into the educational process positively influences the development of graphic literacy, analytical thinking, creative approaches, and independent work competencies. The integrated teaching model reinforces not only students' technical knowledge but also their 21st-century competencies, such as digital literacy, problem-solving skills, and professional adaptability. Overall, teaching projection drawing, views, pictorial representations, and axonometric projections in combination with modern digital tools has been proven to be a methodologically effective, scientifically grounded, and practically significant approach for developing students' spatial thinking.

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