Volume 3, Issue 4, April – 2025 **ISSN (E):** 2938-379X

FORMATION OF KNOWLEDGE AND SKILLS IN DESIGNING SPATIAL IMAGINATION IN STUDENTS IN ENGINEERING GRAPHICS CLASSES

Нурметов Мухтор Рустамович
Доцент

Сейитниязова Айимхан Абдуллаевна
Старший преподаватель
Ургенчский государственный университет

Abstract
To consider methods and techniques aimed at improving spatial thinking in the process of teaching engineering graphics.

Keywords: Education, engineering graphics, training, computer technologies, three-dimensional objects, efficiency, digital technologies, interactive methods, spatial thinking, practical significance, research.

Introduction

Modern engineering education requires not only the acquisition of theoretical knowledge, but also the development of practical skills, among which spatial imagination occupies a key place. This is a cognitive ability that allows you to mentally imagine, analyze and transform three-dimensional objects, which is extremely important for engineers, designers and architects.

Engineering graphics as an academic discipline serves as the basis for the formation of spatial thinking, since it teaches how to work with drawings, projections and 3D models. However, traditional teaching methods do not always provide a sufficient level of visualization, which makes it difficult to understand complex geometric shapes.
Within the framework of the study, the following tasks are set:
1. To determine the role of spatial imagination in engineering and technical activities.
2. To analyze traditional and innovative teaching methods that contribute to its development.
3. To offer practical recommendations for optimizing the educational process.

The relevance of the study is due to the increasing requirements for the training of specialists capable of working with modern CAD systems and complex technical projects. Developed spatial thinking not only facilitates the development of engineering graphics, but also contributes to the successful solution of professional problems in the future.

Web of Teachers: Inderscience Research
webofjournals.com/index.php/1

The article discusses both classical approaches (working with drawings, visual aids) and modern technologies (3D modeling, VR/AR), which allows you to comprehensively assess their effectiveness in the educational process

Body

1. Theoretical Aspects of Spatial Imagination in Engineering Graphics

Spatial imagination is a complex cognitive process that allows a person to mentally imagine, transform, and analyze three-dimensional objects based on their two-dimensional images. In the context of engineering graphics, this ability is manifested in the following key skills:

- Recreating three-dimensional forms according to drawings (reading projections);
- Mental section and transformation of objects (definition of sections, sections);
- Transition between 2D and 3D representations (construction of complex drawings and axonometry);
- Analysis of the relative position of parts (in assemblies and mechanisms).

According to research (e.g., the works of [Ivanov, 2020; Petrova, 2018]), the level of development of spatial imagination directly correlates with the success of mastering engineering disciplines. Students with developed spatial thinking demonstrate:

- Higher speed of interpretation of drawings;
- Fewer design errors;
- Better results in solving visualization problems.

2. Methods and technologies for the formation of spatial imagination

In modern pedagogical practice, the following groups of methods are used:

2.1. Traditional approaches:

- Graphic exercises:
- Construction of the third projection according to two given ones;
- Making cuts and sections;
- Solving positional and metric problems.
- Working with physical models:
- Use of collapsible models of geometric solids;
- Comparison of real objects with their drawings.

2.2. Digital technologies:

- 3D modeling in CAD systems (AutoCAD, Compass-3D, SolidWorks):
  - Step-by-step creation of volumetric models;
  - Analysis of projections from different angles.
- Virtual and augmented reality (VR/AR):
  - Interactive visualization of complex details;
  - Simulators for practicing drawing reading skills.

2.3. Game and interactive methods:
- Geometric puzzles (Rubik's cubes, tangram);
- Quest tasks to find errors in drawings;
- Team competitions in speed modeling.

Table 1. Comparative effectiveness of methods

Method	Benefits	Restrictions
Graphic Tasks	Develop Accuracy, Affordable	Take Time
3D Modeling	Visibility, Quick Correction	Software Dependency
VR Technology	Immersive, Highly Engaged	Expensive Equipment

3. Practical recommendations for the organization of the educational process

To optimize the formation of spatial imagination, it is proposed:

1. Step-by-step complication of tasks:

- From simple geometric solids (cube, pyramid) → to complex details (body elements, mechanisms).

2. Technology Integration:

- Combination of hand drawing and digital modeling;
- Use of mobile applications for training (for example, Geogebra 3D).

3. Diagnostics and control:

- Conducting input/output testing (Mann-Gupta tests, mental rotation tasks);
- Analysis of typical errors (confusion of projections, incorrect definition of sections).

4. Motivational mechanisms:

- Introduction of gamification elements (points for speed and accuracy);
- Demonstration of real examples from industry (how drawings are turned into products).

Key conclusions of the section:

- Spatial imagination is a basic skill for an engineer, formed through a system of special exercises.
- The greatest efficiency is achieved with a combination of traditional and digital methods.
- The introduction of VR/AR and CAD requires the adaptation of curricula, but gives a significant pedagogical effect.

Conclusion

The study confirms the key role of spatial imagination in the professional training of future engineers and the need for its purposeful development in the process of teaching engineering graphics. The analysis of theoretical foundations and practical methods allows us to draw the following conclusions:

1. Spatial thinking is a complex cognitive skill formed through a system of interrelated exercises - from simple drawing to complex 3D modeling. Its development directly affects the quality of mastering engineering disciplines.
2. The most effective teaching methods combine:
- Traditional approaches (working with drawings, visual aids);
- Digital technologies (CAD systems, VR/AR);
- Interactive forms (game tasks, competitive elements).
3. It is critically important:
- Gradual complication of tasks;
- Regular diagnostics of the level of skill formation;
- Connection of educational tasks with real engineering practices.

Prospects for further research may be related to:
- Development of standardized tests to assess spatial reasoning;
- Study of the effectiveness of neurotechnologies in teaching visualization;
- Creating adaptive curricula that take into account the individual characteristics of students.

The introduction of these approaches into the educational process will not only improve student performance, but also train specialists who are able to solve complex project problems in the context of the digital transformation of production.

The practical significance of the study lies in the fact that the proposed methods can be adapted for different levels of education, from school drawing courses to advanced training programs for engineers.

References

1. Ivanov A.V., Petrova S.K. Metodika prepodavaniya inzhenernoy grafiki v tekhnicheskoy vuze [Methods of teaching engineering graphics in a technical university]. Moscow: MSTU Publ., 2020. 215 p.
2. Sidorov N.N. Spatial thinking and its development in engineering education. — St. Petersburg: Polytechnic, 2018. 180 p.
3. Fedorov L.B., Kozlova E.M. Digital Technologies in Engineering Graphics: CAD, VR and AR. — Novosibirsk: Nauka, 2021. — 264 p.
4. Mann G., Gupta R. Diagnostika prostranstvennykh sposobnosti: testy i metodiki [Diagnostics of spatial abilities: tests and methods]. Moscow: Pedagogy, 2019. — 112 p.
5. Zhukov V.P. Interaktivnye metody obucheniya graficheskim distsiplinam [Interactive methods of teaching graphic disciplines]. — Kazan: KSTU, 2022. 145 p.
6. Petrova S.K. Razvitie prostranstvennogo voobrazheniya u studentov tekhnicheskikh spetsial'nosti [Development of spatial imagination in students of technical specialties]. — 2018. — № 4. — S. 45–52.
7. Belov A.A. Primenenie VR-tekhnologii v kurs inzhenernoy grafiki [Application of VR technologies in the course of engineering graphics]. — 2021. — № 3. — S. 78–85.
8. Gusev V.A. Psikhologo-pedagogicheskie osnovy razvitiya prostranstvennogo myshleniya [Psychological and pedagogical foundations of the development of spatial thinking]. Moscow, Akademiya Publ., 2017. 200 p.

9. Rodionov M.I. Engineering Graphics: From Drawing to 3D Models. — Yekaterinburg: USTU-UPI, 2020. 176 p.
10. ISO 128-1:2020 Technical drawings — General principles of presentation. — Geneva: ISO, 2020.