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SCIENTIFIC AND METHODOLOGICAL BASIS FOR DEVELOPING STUDENTS' SPATIAL CONCEPTS WHEN TEACHING THE TOPIC "CUTTINGS AND SECTIONS" IN THE COURSE OF ENGINEERING GRAPHICS

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Abstract:
The article is devoted to methodological approaches to teaching sections and cross-sections, as well as an analysis of their role in the development of spatial thinking. Various teaching methods are considered, including visualization, modeling and the use of software, as well as the influence of pedagogical technologies such as virtual and augmented reality on the understanding and perception of three-dimensional objects. Particular attention is paid to the integration of theory and practice, as well as the importance of examples and practical tasks in the learning process. The article also offers scientific and methodological recommendations for improving teaching, and discusses prospects for further research and development of the topic in the field of education**.**

Key words: Sections, cross-sections, spatial thinking, pedagogical technologies, visualization, modeling, software, virtual reality, augmented reality, teaching methods, integration of theory and practice**.**

Introduction

Engineering graphics is one of the fundamental disciplines in technical and engineering education, which occupies a key place in the training of specialists. It serves as a language through which engineers and designers convey their ideas and solutions. During their studies, students master the skills of depicting objects, diagrams, drawings, and also learn to analyze and interpret graphic materials [1].

The main tasks of engineering graphics include developing students' ability to accurately and clearly depict technical objects, as well as skills in working with drawings and design documentation. This allows future specialists to effectively interact with colleagues and partners, as well as understand and create design solutions.

Spatial representations are the most important component of thinking, which helps a person perceive and comprehend objects and their location in three-dimensional space. In engineering graphics, these skills are especially relevant, since students must be able to represent objects not only in a flat form, but also in volume, and also understand how various elements interact with each other in real space [3].

Developing spatial awareness helps students see how shapes of objects change in different projections, as well as how they can be transformed, for example, when creating sections and cross-sections. This knowledge is necessary for engineers to accurately interpret drawings, create correct design solutions, and successfully work in three-dimensional models.

Developing spatial awareness in students is critically important, since it is directly related to their professional training. In the process of work, engineers often face the need to quickly and accurately perceive and change the shapes of objects, as well as understand their structure and behavior in space. Without developed spatial skills, it is difficult to effectively work with engineering documentation, design complex mechanisms, structures, and systems [3].

Spatial awareness helps students not only in their studies, but also in practical work, since most engineering projects require specialists to be able to see objects in different projections, work with drawings and models, and draw conclusions based on their analysis. The development of spatial perception is especially important when studying the topic "Cuts and Sections", which requires students to be able to imagine and analyze the internal structure of objects and their elements, which is impossible without a sufficient level of spatial imagination. This ability becomes the basis for further mastering complex topics in engineering graphics and other technical disciplines.

Theoretical foundations of spatial representations. Understanding Spatial Representations: What Are They and How Do They Affect the Perception of Graphic Objects?

Spatial representations are cognitive processes by which a person perceives, understands, and reproduces objects in three-dimensional space. This is the ability to “see” objects not only in two-dimensional form (for example, on

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paper), but also to imagine them in volume, to understand their sizes, shapes, locations, and possible changes. Spatial representations are an important component of the mental process, since they allow a person to "transfer" objects from imaginary space to real space and vice versa.

In engineering graphics, the space between objects and their shapes play a key role. In order to accurately display details on drawings or in models, it is necessary to be able to imagine them in three-dimensional form. This is due to the perception of objects not only as two-dimensional images, but also as elements of volumetric structures that can interact with each other. For example, sections and cuts are ways of displaying the internal parts of objects that require students to be able to "cut out" and "see" the internal elements, despite the fact that they are inside a three-dimensional figure [13].

Correct perception of the spatial characteristics of objects helps students analyze and interpret drawings, model structures, and make decisions on their further development. Without developed spatial representations, it will be difficult for students to accurately understand how the depicted object looks in reality, as well as how its parts interact.

Spatial representations can be divided into several types, depending on which feelings and perceptions prevail in the process of their formation. Let's consider the main types:

1. Visual representations. Visual representations are the main ones in the context of engineering graphics, since drawings, diagrams and blueprints are primarily visual objects. Students must be able to "see" an object in their imagination, imagining it in different perspectives and projections, and then accurately transfer this image to a plane. Visual representations help to visualize the shape and volume of an object, which is extremely important when studying sections and cross-sections, when it is necessary to imagine what the internal structure of an object will look like if it is divided or cut out.

2. Kinesthetic representations. Kinesthetic representations are associated with the perception of movements, sensations from interaction with objects. In engineering graphics, this type of representation is important when modeling and creating three-dimensional objects, when the student can feel and perceive objects through tactile sensations. For example, when creating physical models

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that are then used to take dimensions or create drawings, the student can feel the shape and structure of the object with his hands. This helps to develop a practical perception of spatial objects and their interactions.

3. Motor representations. Motor representations are associated with the movement and change of position of objects in space. In the context of engineering graphics, this means the ability to "move" or "rotate" objects in your imagination to better understand their spatial arrangement. This can be useful, for example, when analyzing how various elements of a design can be located relative to each other or changed during the design process.

4. Verbal representations. Verbal representations are associated with how a person describes objects in words. This is important when it is necessary to understand how one object relates to another, or when it is necessary to explain the structure of an object using engineering graphics terms and concepts. For students, this is a useful skill that helps them work with drawings, diagrams, and other visual aids if they are accompanied by text explanations.

5. Geometrical representations. Geometrical representations are the ability to perceive and analyze the shapes and structures of objects in terms of their geometric characteristics. In engineering graphics, this helps students analyze the sizes, proportions, and relative positions of object elements, which is especially important when creating sections and cross-sections.
How do spatial representations affect the perception of graphic objects?
The development of spatial representations significantly affects the ability of students to correctly perceive and interpret graphic objects. These representations help:
- Accurately reproduce objects in drawings and models.
- Understand how the shapes of objects change when moving from one projection to another.
- Create correct sections and cross-sections, understanding what the object will look like when its structure or shape changes.
- Make the transition from abstract images to real objects.

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Thus, the development of various types of spatial representations contributes to a deeper understanding and perception of engineering graphics, which helps students not only in their studies, but also in their future professional activities.

3. Sections and Cuts Topic in Engineering Graphics

Problems Solved with Sections and Cuts. Sections and Cuts are the most important tools of engineering graphics used to display the internal structure of objects. This technique allows you to "split" an object to demonstrate its internal elements that cannot be seen from the outside and to understand how they interact with each other. The Sections and Cuts topic solves the following problems:

1. Representation of the internal structure of objects. One of the key tasks of sections and cuts is to visualize the internal structure of objects such as buildings, machines, mechanisms and other technical products. This allows you to study the location of components, their interactions, and identify hidden defects or potential problems in more detail.
2. Simplification of perception of complex objects. When an object has a complex shape or consists of many elements, a simple image of its appearance may not give a complete idea of its design. With the help of sections and cuts, you can simplify perception by presenting only those parts that are important for understanding the operation or structure of the object.
3. Accurate dimensions and proportions. Sections and cuts allow you to accurately display the dimensions and proportions of the internal elements of an object. This is especially important in design, when you need to meet strict geometric and functional requirements so that all the parts fit together and work as a whole.
4. Explaining the principles of operation of a device. In engineering graphics, sections can be used to demonstrate the operating principles of various mechanisms, such as engines, pumps, hydraulic systems, etc. This allows you to understand how the elements interact and how energy or movement is transferred.
5. Simplifying the manufacturing process. Correct use of sections and cuts allows you to accurately convey information about the internal structure of an object, which facilitates its production and assembly. Drawings with sections

help workers and engineers understand exactly how to connect elements, what components should be used, and what the dimensions of these parts are.

There are several types of sections and cuts, each of which is used for different purposes in engineering graphics. Let's consider the main ones:

1. Straight section. This is the simplest and most common type of section. It is made in a straight line through an object, allowing for a clear view of its interior. A straight section is typically used to show the internal structure of mechanical and structural objects.
2. Oblique section. This type of section is made at an angle to the object's axis, allowing for a view of the interior of an object that has a complex shape. An oblique section is used when a straight section cannot effectively display the desired details.
3. Notched section. In this case, the object is not shown in full volume, but with notches or partial "cutouts" to show only the important elements. Notched sections are often used in complex designs where only certain areas need to be shown.
4. Multiple Sections. This is a technique where multiple sections are taken at different levels of an object to show different aspects of its internal structure. This type is used to analyze complex objects that consist of multiple layers or parts in more detail.
5. Overlay Section. In some cases, sections can be combined with other images, such as views or perspectives, to give a more complete view of the object. This is important for objects with unusual or complex geometry.
6. Projected Sections. Such sections help to show how an object will look if it is divided into several parts, and then display these parts in projections so that they correspond to the real shape of the object.

Studying sections and sections in engineering graphics can be quite complex, and students often face a number of problems:

1. Lack of spatial imagination. One of the main difficulties for students is the inability to imagine how an object will look after it is “cut”. This requires developed spatial representations, which must be trained and developed. For students who cannot “imagine” an object in 3D, understanding cuts and sections can be challenging.
2. Difficulty understanding cut types. Each cut and section type has its own rules and principles for execution, which can be confusing for students. For example,

when working with oblique or complex cuts, it is important to correctly account for the angles and position of the object to maintain accuracy.

3. Errors in data interpretation. Sometimes students make mistakes in interpreting cuts and sections, misunderstanding their purpose or overlooking important details. This can lead to errors in design or analysis.

4. Misunderstanding the relationship between projections and cuts. Students may have difficulty linking visible projections of an object and its cuts. This is because cuts can show internal parts that are not visible in standard projections, and students must learn to interpret this information correctly.

5. Inability to apply theory in practice. Theoretical knowledge of sections and cross-sections often does not coincide with real design tasks, which makes the transition from theory to practice difficult. The importance of practical tasks and models for understanding sections becomes obvious.

Thus, it is possible to explain the importance of sections and cross-sections in engineering graphics and why they are indispensable tools for analyzing and designing objects. It also identifies the main difficulties that students face, which allows developing approaches to improve teaching on this topic.

Understanding the difference between a section and a cut is one of the key tasks in teaching engineering graphics, and it is important that students correctly understand where and when to apply each of these techniques. It is important to emphasize their differences and use illustrative examples so that students can quickly and accurately choose which method to use in a given situation [12].

Let's break this down into simple, understandable steps:

The difference between a cutaway and a section. Section. What is it? A section is a method of drawing an object by "cutting" it along an imaginary line (usually a straight line). The result is an image of the inside of the object, as if it were divided into two parts, and only one of them is shown.

What does it look like? In a drawing, a section is usually indicated by a line that runs through the object, and can be done along one axis (horizontal or vertical). The section line itself is often indicated by arrows or other symbols.

When is it used? A section is used when it is necessary to show what the inside of an object looks like along a certain line. This is useful for objects that have a complex internal structure, such as mechanisms, pipes, housings, where it is important to demonstrate what is inside, and not just the external appearance.

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Example: Mechanical parts - a section shows how the components inside the device are arranged, such as the internal structure of a motor. Buildings and structures - a section shows the number of floors, the location of walls, columns and other elements.

Section. What is it? A section is a method of displaying part of an object, as if we were "cutting out" a part of it and showing it in section. A section is often used when it is necessary to show not only the internal structure, but also the shape or contours that are hidden from direct view.

What does it look like? A section is most often performed not along a single line, but along a certain area of the object. The drawing shows not just individual lines, but the entire section of the object, usually with additional hatching or filling for clarity.

When is it used? A section is used for more complex tasks, for example, when it is necessary to show details of the internal structure of an object, including the shape and contours of its elements. Sections are often used for images that require greater detail of internal characteristics.

Students may have trouble understanding when and which image to use, so it is important to offer them tasks where they need to decide when to use a section and when to use a section. For example, ask them to draw a section and a cross-section of the same object so that they can see the differences and learn to choose the right method.

A good method is to analyze typical mistakes students make. For example, you can show an example where a section is used where a section would be correct, and vice versa. This helps students learn to make the right choice in practice.

When to use a section? When you need to show only one internal element of an object along a certain line. When the object has a simple structure, and it is enough to show part of its cross-section. For a simplified representation of objects where only one aspect is important (for example, the inside of a pipe).

When to use a section? When you need to show a more complex internal structure of an object or a whole set of elements that are not visible from the outside. For objects with multiple layers or internal parts that need to be shown in more detail. For objects with volumetric elements, where it is necessary to demonstrate their shape and relative position.

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These explanations and approaches will help students more accurately understand when and which methods to use, and will also teach them to correctly perceive the difference between sections and cross-sections.

Methodological approaches to teaching sections and cuts play a key role in understanding and mastering these concepts, especially in fields such as geometry, engineering, architecture and other disciplines related to spatial perception [10]. Let us consider each of these aspects in detail:

1. Using different teaching methods (visualization, modeling, use of software)

Visual teaching methods help students form a clear understanding of sections and cuts, making abstract geometric concepts more visual. This may include:

- Illustrations, diagrams, 3D graphics.
- Multimedia materials such as video tutorials or animations.
- Modeling: Using physical models or digital simulations allows you to create tangible objects that can be "cut" or "cut", observing how the shape of the object changes. For example, students can work with a model of a polyhedron, modeling different sections through it.
- Use of software: Modeling and visualization programs such as AutoCAD, SolidWorks, SketchUp, and others allow students to create and modify 3D models of objects. Such programs make it easy to make cuts and sections, which allows students to experiment with them in real time and see their results in a virtual environment [6].

2. The Role of Examples and Practical Tasks in the Learning Process

- Examples: Providing multiple examples of sections and cross-sections of objects helps students understand the variety of possible situations. Real-life examples, such as sections of buildings, machines, the human body, or natural objects, make the material being studied more accessible and interesting.
- Practical Tasks: Actively involving students in the process of solving problems related to sections and cross-sections helps develop spatial imagination skills. Tasks may include:
- Constructing cross-sections through geometric bodies (e.g., through a cube or cylinder).
- Studying cross-sections of complex objects, such as multi-story buildings or engineering structures.

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- Real projects that require the use of sections and cross-sections to demonstrate the internal structure of objects.

Practical classes not only improve theoretical knowledge, but also develop analytical thinking and the ability to work with 3D data.

3. The Impact of Pedagogical Technologies on the Development of Spatial Representations. Pedagogical technologies such as interactive learning, gaming technologies, and the use of VR (virtual reality) and AR (augmented reality) significantly enhance the development of spatial representations in students [9]. Students can independently work with and manipulate various objects in real time, which helps develop visualization skills. For example, the use of touch screens or interactive whiteboards allows students to "draw" a section or cross-section and see it change in response to their actions.

Some educational platforms offer gamification elements, where students can solve problems on cross-sections in a game-like manner. This increases motivation and makes learning more fun.

Virtual reality allows students to immerse themselves in a 3D space and interact with objects, creating and exploring cross-sections and cross-sections in real time. Augmented reality can superimpose virtual objects on the real environment, which helps make cross-sections more visual and understandable [4].

Thus, the use of methodological approaches such as visualization, modeling, software, and the introduction of pedagogical technologies have a great impact on the effectiveness of mastering sections and cross-sections. These methods help to form strong spatial representations and the ability to solve complex problems in various fields in students. Scientific and methodological recommendations for teaching the topic "Sections and Cross-sections" are aimed at developing spatial thinking and skills in working with geometric figures, which is especially important for students studying in areas such as engineering, architecture, geometry, and mathematics. Let's consider the main recommendations that can improve the effectiveness of teaching this topic.

Recommendations for improving the teaching of the topic "Cuts and Sections" taking into account the development of spatial representations

- Using multi-level approaches: It is important to take into account that each student has their own level of spatial perception. For effective teaching, it is

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necessary to use a variety of methods, ranging from simple objects to more complex ones. Example:
- At the initial stages of teaching, it is worth working with simple geometric shapes (e.g., cube, cylinder, cone), gradually moving on to more complex objects.
- Gradually include tasks that require the analysis of complex polyhedrons, as well as working with three-dimensional visualizations and models.
- Supporting the development of spatial thinking through different types of activities: It is important to organize training in such a way that it includes active types of activities that help develop spatial representations:
- Modeling objects (both in real life and in a virtual environment).
- Completing tasks with 3D materials, for example, constructing sections in three-dimensional models.
- Using practical laboratory work and projects in which students directly work with real or modeled objects.
- Focus on understanding the importance of sections and cross-sections in real life: Teaching the topic of sections and cross-sections will be more effective if it is related to real-life applications, for example, in construction, architecture, biology (anatomy), engineering, etc. It is important to show how sections and cross-sections help to understand the internal structure of objects and solve applied problems.

Integrating theory and practice in teaching sections and cross-sections plays an important role in forming a deep and meaningful understanding of the topic [11]. It is important that students can not only learn the theoretical foundations, but also apply them in practice.
- Theoretical training: Students should clearly understand the basic theoretical concepts of sections and cross-sections: how they are constructed, what types of sections exist (flat, volumetric), what a section of an object is, how to interpret the results obtained. It is important to explain how and why sections are used in different fields.
- Practical application: An equally important aspect is the practical application of theoretical knowledge. These may include:
- Practical assignments involving the construction and analysis of sections of geometric bodies.
- Using software to model and analyze sections in three-dimensional objects.

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- Carrying out real projects, such as creating sections of complex architectural objects or engineering structures.

The combination of theory and practice allows students not only to understand abstract theoretical principles, but also to learn how to use them in real-life tasks. Modern technologies can significantly improve the effectiveness of teaching sections and sections by improving the perception and understanding of spatial objects. Among such technologies, the following can be highlighted:

- Modeling software: Programs such as AutoCAD, SolidWorks, Blender allow you to create 3D models of objects and perform various sections, sections, and visualizations. Using these programs helps students see how the object changes when cut and better understand the internal structure.
- Virtual reality (VR) and augmented reality (AR): These technologies can completely transform the learning process by creating an immersive environment for working with three-dimensional objects. Students can "dive" into objects and "cut" them, exploring their internal structure interactively. For example, in a VR environment, you can easily and clearly imagine different cuts of complex objects, such as buildings or cars, and change the angle of the cut to see different details.
- Interactive platforms and resources: Modern educational platforms, such as GeoGebra, offer tools for working with geometric shapes and sections. This allows students to independently experiment with cuts, setting the parameters of objects and the type of section, which helps to improve visualization and deepen understanding of the material.
- Multimedia materials and animations: Animations and videos that demonstrate how different types of cuts and sections are performed can significantly improve the perception of information. Such materials make the learning process more exciting and visual.

Methodological recommendations aimed at improving the teaching of the topic "Cuts and Sections" should include a variety of approaches that are focused on the development of spatial representations and an effective combination of theory and practice. The introduction of modern technologies such as software, VR and AR, as well as the use of multimedia materials, helps to improve the perception and understanding of spatial relationships and significantly accelerates the learning process.

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Conclusion

The topic of "Cuts and Sections" is an important part of the educational process in the field of mathematics, engineering, architecture and other disciplines related to spatial perception and analysis of objects. In the process of teaching this topic, the main focus is on developing students' skills in working with three-dimensional figures and the ability to interpret cuts and sections as a way to visualize the internal structure of objects.

We considered several key aspects that contribute to effective teaching of cuts and sections:

1. Methodological approaches - the use of visualization, modeling, software, as well as the integration of theory and practice to develop spatial representations.
2. The role of examples and practical tasks - through examples and practical exercises, students gain experience that helps them not only learn the theoretical foundations, but also apply them in practice.
3. The influence of modern technologies - the use of digital technologies such as 3D modeling, virtual reality (VR) and augmented reality (AR) significantly improves the perception of complex spatial relationships and makes the learning process more exciting and effective. 4. Scientific and methodological recommendations—development of spatial thinking through multi-level approaches, integration of theory and practice, and the use of technologies that promote a deeper understanding of sections and cross-sections. An important aspect that is emphasized in the work is that successful mastery of the topic is not limited to the ability to construct cross-sections, but also includes the development of critical and analytical thinking, the ability to see complex objects from different angles and contexts.

Prospects for Further Research and Development of the Topic

Future research and development of the topic "Sections and Sections" should take into account several key areas:

1. Development of educational technologies: Continued development and implementation of new educational technologies, such as more advanced platforms for 3D modeling, VR and AR, which will allow for in-depth study of not only simple geometric shapes, but also complex engineering and architectural objects. The interactivity of such technologies helps students better absorb information and understand abstract concepts.

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2. Personalized learning: Given the diversity of levels of spatial perception and different approaches to learning, it is important to develop personalized teaching methods. This may include the use of adaptive educational platforms that, based on an analysis of the student's progress, offer tasks and exercises that are appropriate for their level of development.

3. Integration with other disciplines: The use of sections and sections goes beyond purely mathematical disciplines. It is important to develop an interdisciplinary approach that will integrate knowledge of sections and cross-sections into architecture, biology, medicine, artificial intelligence and other fields. For example, in medicine, the use of sections based on 3D scanning helps doctors analyze the anatomical structures of the body.

4. Use of artificial intelligence: In the future, it is possible to use artificial intelligence (AI) to automatically create and analyze sections of complex objects. AI can help improve the understanding and perception of various types of sections, offer optimal solutions in the design and analysis of various structures.

5. Research in the field of psychology of perception**: The topic of sections and cross-sections is closely related to the development of spatial perception, which opens up opportunities for further research in the field of cognitive psychology. Studying how different people perceive spatial objects can lead to improved teaching methods and the creation of more effective educational technologies.

6. Development of standards and recommendations for teaching: It is important to continue research and development of scientifically based standards and methodological recommendations that will be adapted to the changing conditions of education and the use of new technologies. These standards may include not only teaching methods, but also criteria for assessing students' knowledge and skills, which also contributes to improving the quality of education. The topic "Cuts and Sections" continues to be key in educational programs that require spatial thinking and the ability to work with 3D objects. Methodological approaches, the use of modern technologies and scientific and methodological recommendations play a decisive role in effective learning. Further research in this area, as well as the introduction of new technologies and interdisciplinary approaches, will contribute to further improvement of educational processes and the quality of students' training, developing their ability to solve complex problems in various fields of science and practice.

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