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FORMATION OF SPATIAL AND GEOMETRIC THINKING AMONG ENGINEERING STUDENTS

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Abstract

The formation of spatial and geometric thinking among students of technical specialties is an urgent problem of training highly qualified engineers capable of solving important non-trivial technical problems. The modern world is changing rapidly, giving rise to a shortage of real specialists. There is an increasing need to create comfortable, understandable guidelines for everyone in behavior tactics during the training of an engineer. In this regard, the need to solve problems associated with the formation of skills in spatial-geometric thinking is becoming increasingly important. Practice shows that modern higher education can be regarded as an object of high performance. Therefore, the question of the formation of students' spatial and geometric thinking in the process of studying special disciplines and the interaction of all participants in the educational environment is very relevant. In our opinion, a properly delivered education in engineering can significantly increase a number of qualified specialists in our country. Currently, there is no general and precise concept or definition of spatial-geometric thinking. The issue of improving the student's spatial and geometric thinking is the focus of numerous works on the methodology of teaching a course in special engineering disciplines, both in Russia and in other countries.

Keywords: Thinking, engineer, space, system, quality

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1. Introduction

Spatial thinking is about content and great opportunities to:

- perceive and develop a form of spatial and geometric thinking of students using information technologies and experimental verification of their effectiveness.
- develop a specific approach to the process of forming students' spatial-geometric thinking.

An important role in the development of a student's thinking is played by the cognitive processes of perception, sensation, orientation in space, as well as methods of forming spatial-geometric thinking of students in engineering fields.

Today, the expansion of spatial and geometric thinking should build a process that develops the function of teaching special disciplines. In the learning process, it is required to take into account the prerequisites of abilities, that is, the innate inclinations of students. Ability or inclinations are not a guarantee of independent development and formation of spatial-geometric thinking.

It is assumed that the effective formation of spatial-geometric thinking is possible if the peculiarities of the development of students' abilities for the spatial-geometric solution of complex graphic problems are taken into account; the training program includes a set of requirements and a system of methodological provisions, educational tasks and organizational and pedagogical measures that take into account individual characteristics in project activities of students (Dzhalchinova et al., 2019).

The topic of spatial and geometric thinking is observation, conversation, questioning, polling, testing, experimental methods.

Thus, the development of a set of methods will optimize the process of forming strategies for spatial-geometric thinking to:

- substantiate systems for solving engineering problems when teaching students the basics of spatial and geometric thinking;
- develop the ability to apply the developed model of the formation of students' spatial-geometric thinking.

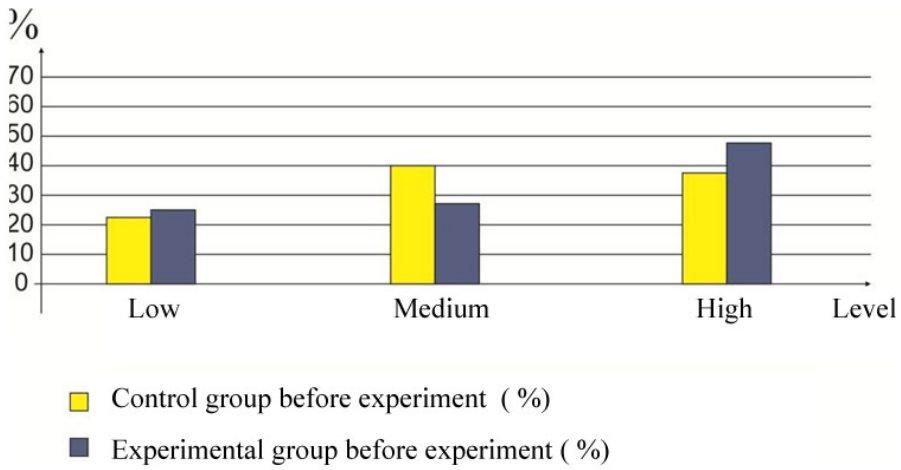

Figure 1. Experiment statistics
Control group before experiment (%)
Experimental group before experiment (%)

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2. Problem Statement

The study and consideration of psychological, pedagogical and special literature made it possible to reveal the contradiction between the need of modern society to improve the quality of spatial and geometric thinking of students – future engineers and the established classical system of education at the university, which does not solve this problem.

Research objectives:

1. Study the essence of spatial-geometric thinking of a student's personality.

2. Reveal features of the formation of spatial-geometric thinking as a component of the content of professional education among future engineers in the humanitarian model of education.

3. Develop and implement a humanitarian model for the formation of spatial-geometric thinking among engineering students.

4. Conduct experimental work on the formation of spatial-geometric thinking among engineering students.

The topic of spatial and geometric thinking is observation, conversation, questioning, polling, testing, experimental methods.

3. Research Questions

The importance of spatial and geometric thinking is associated with the modern capabilities of artificial intelligence systems and information support for engineering specialties. In many ways, three-dimensional modeling and work with spatial figures is the basis of modern intelligent systems. The student's inability to think in spatial-geometric categories creates a serious problem of realizing the student's potential and achieving his professional goals. The capabilities of modern information systems are becoming unclaimed, the student lacks the necessary understanding of the process and the result of solving the problem, supported by spatial geometric representations.

The widespread introduction of multidimensional modeling methods in engineering areas makes it necessary to develop integration trends in the educational process, which involves the development of modern and progressive methods of spatial and geometric thinking (Baydenko, 2004).

The need for such training is dictated by manifestations of the first professional intentions and strengthening of the motivational aspect of choosing the future profession by the applicant; then the student, encouraging him to act, the focus of his training on self-identification as an engineer. The research methods used to solve the set tasks: theoretical – analysis of spatial-geometric competences, their role in general construction training and practical activities of an engineer; diagnostic – collecting information based on a survey, conversation, observation during the educational process from the position of a teacher; mathematical and statistical methods for processing experimental data.

4. Purpose of the Study

The aim of the study is to create and disclose a clear classification of problems in descriptive geometry, engineering and computer graphics for the development of spatial-geometric thinking, when

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learning to solve problems, allowing to provide an openwork selection of a minimum number of problems with a system of algorithms for their solution, contributing to the rapid formation of spatial-geometric thinking among students of engineering fields.

5. Research Methods

The method of teaching the basics of projection modeling (descriptive geometry) is based on the refusal to rely on visual images when performing diagrams. The task of the teacher is to teach students consciously perceive a mental representation of an object in projections (before the image on the diagram), that is, teaching students to create an image of the imagination. For this purpose, a special teaching method has been developed, which provides for explaining to students the principle of projection using visual aids: visual models, a triangular angle, images of projection planes using electronic means or on a board – with a gradual rejection of them and replacing real actions with mental ones. As a result, this leads to the fact that the actions dismembered in time are combined into a single act and a complete transition to the direct presentation of projections and their operation. Thus, schematically, the process of forming the skills of performing the plot requires: from the teacher – showing the technique, bringing it to awareness, teaching the mental drawing up of projections and organizing the transfer; from students – assimilation of the shown technique, its awareness, mental performance, which ultimately leads to using the technique "automatically". It should be noted that there is also a transition from "external" actions to mental ones (but the "external" actions themselves are different – they are based not on manipulations with any object, but on the fundamental principles of the projection method) and the need to operate with representations is affirmed. In this process, the dynamic moment of spatial imagination is of great importance, since it is this side of the spatial representation that is most difficult for students (Zimnyaya, 2003). As a result of the analysis of theoretical, scientific, methodological and psychological-pedagogical literature, as well as the experiment and our own pedagogical experience, we came to the conclusion that to solve this problem it is necessary to provide a set of pedagogical conditions, including:

- multilevel content of educational activities — different aspects of educational information should be focused on different types of cognitive experience of students, as well as on various components in the structure of the cognitive experience of each student (Baydenko, 2004; Dzhalchinova et al., 2019; Verbitsky, 1991);
- psychological characteristics of the spatial representations of students and the patterns of their development; cognitive-style characteristics of students in teaching (Arkhangelsky, 1980; Baydenko, 2004; Verbitsky, 1991);
- development and application of a didactic support system that implements the task by means of an academic discipline, since the formation of spatial representations should be carried out in an inextricable connection with the study of the discipline;
- necessary educational information and the forms of its presentation should have a clear focus on certain modalities of the mental experience of the individual (Verbitsky, 1991; Vilensky et al., 2005);
- intensification of learning (both innovative and traditional means).

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The formation of spatial representations is provided by means of educational disciplines (descriptive geometry, mathematics), by means of geometric modeling (applied geometry, engineering and computer graphics), further develops and improves in the development of special disciplines of the design cycle. Thus, the enrichment of the intellectual resource of the individual with the ability to operate with spatial images meets the task of higher professional education – the upbringing of a highly intellectual, creative, and competitively capable specialist.

6. Findings

Two groups of students studying in the direction 08.03.01 Construction were involved in the experiment, control – 82 people, experimental – 74 people (158 people in total) with approximate indicators of input control.

The total number of students participating in the research is as follows: 97 % – students have undergone spatial-geometric pre-university training according to programs, of which 48 % are students of a specialized class or studied according to an individual program that includes basic elements of descriptive geometry; 49 % of students completed general preliminary training in the preparatory courses in drawing, aimed at studying the techniques of geometric drawing and the construction of orthogonal projections, which is necessary for the successful passing of the entrance examination in drawing; 3 % did not have official pre-university training (preparatory courses), but studied individually according to the program of preparatory courses, of which 0.02 % had no preparation, they entered an architectural university due to a coincidence of circumstances and natural talent.

The research was carried out on the basis of sequential execution of comparative pedagogical experiments. The methodology for organizing the dissertation research is substantiated by the theoretical provisions discussed earlier.

The experimental work was carried out in three stages: ascertaining, forming and control, with subsequent analysis of the results obtained.

The purpose of the ascertaining experiment, which was carried out at the beginning of the 1st semester, was to determine the preliminary level of the formation of spatial-geometric competencies among engineering students and their focus on further professionalization of education. The tasks for achieving the goal consisted in the analysis of the initial level of the formation of spatial-geometric competence, determination of the composition of the experimental (EG) and control (CG) groups.

The qualitative characteristic of formation in this case depends on the motivation of training, interest in the future profession. Thus, a motivational criterion was used to identify professional interest.

Students were asked to divide the factors of attractiveness or unattractiveness of professional activity into two groups: A – factors of attractiveness, B – factors of unattractiveness. The significance coefficient is calculated for each factor. Comparison of two groups of first-year students at the beginning of training (control CG and experimental EG) was made to reveal their focus on self-identification in the chosen field of activity.

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7. Conclusion

The study confirmed the relevance of the topic under study, the hypothesis, and solved the tasks. Evaluation and analysis of the results obtained led to a conclusion.

The levels of formation of spatial and geometric competencies are assessed using the following proposed criteria: motivational criterion (interest in the future profession, understanding the importance and incentives for obtaining professional geometric and graphic training, assessment and comprehension of the result of one's work, self-identification as a member of the architectural community); practical-activity criterion (the ability to apply, integrate the acquired knowledge in professional and educational-cognitive activities); cognitive criterion (level of theoretical knowledge, mastering the conceptual apparatus of descriptive geometry and graphics, methods and techniques of architectural visualization, knowledge and understanding of the geometry of shaping).

The developed model of the formation of spatial and geometric competencies in future engineers includes target, meaningful, procedural, diagnostic and resultant components in their unity and has a special theoretical and practical significance. The implementation of the developed model is carried out on the basis of strategies (active interaction of participants in the educational process by approaching the activities of an engineer; development of practical design skills through identifying the geometric-graphic component of the implementation of an architectural project; comprehensive support of students, contributing to the development of skills in independent activity) and the principles of conceptuality, constructivism, kinship compliance, revitalization and independence, similarity of project activities.

The modified design-analogous method of teaching the geometrographic disciplines of a future engineer, as a component of general construction training, is based on the structure of professional (educational and professional) activities, which is based on the design or creation of a project ("the engineer method").

The conclusions of the study are aimed at assisting university teachers in order to improve the quality of the formation of spatial-geometric competencies of future engineers and to use practice-oriented teaching methods in other specialized disciplines.

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