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A Modular Competency-Based Approach To Developing Students' Spatial Imagination

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ABSTRACT

The article highlights the development of students' spatial imagination on the basis of a modular competency-based approach and presents methodological recommendations related to it.

Keywords: Competent, module, spatial imagination, thinking, research, drawing, methodology, concept, literacy.

INTRODUCTION

Modular competency-based education is a form of instruction built on a special program that includes a target curriculum presented to the student, an information bank, and methodological guidelines for achieving the specified didactic goals. This type of education differs from other forms in that: the content of instruction is presented as complete, independent modules; and interaction between teacher and learner is carried out on fundamentally new foundations. Before each meeting with the teacher, the learner, using the module, brings their initial preparation to a certain level, taking into account their individual abilities for gaining knowledge.

In the state educational standards of higher education, a module is defined as "mutually interconnected and logically complete academic subjects and their components aimed at achieving a specific goal and outcome of teaching and upbringing."

By its nature and didactic potential, a modular competency-based educational program ensures integrity, relative independence and logical completeness of content; flexibility of structure; efficiency of monitoring and assessing learning outcomes; and the achievement of clearly defined goals in forming and developing the professional competencies of the learner, whether a future or currently practicing specialist.

In the process of teaching general professional subjects on the basis of a modular competency-based approach, the use of all teaching methods and tools ensures the development of students' spatial imagination.

According to the curriculum of higher education institutions approved for the 2025–2026 academic year, a total of 150 hours are allocated to the subject Descriptive Geometry and Engineering Graphics taught in the 60111300 – Technological Education program, of which 20 hours are lectures, 40 hours are practical classes, and 90 hours are independent study.

The technology for designing the content of educational programs for organizing technological education on the basis of a modular competency-based approach is as follows:

1. in cooperation with employers, a list of the main functions of the specialist to be trained in a specific field of study is determined;

2. a set of special professional graphic, design, constructive, and technological competencies that are necessary and sufficient for performing the defined

functions is identified;

3. based on theoretical knowledge, a set of typical professional tasks, problems, and situations is designed as a model foundation for the practical actions and work that the student must be able to perform;

4. a system of educational modules is developed that includes the goals and content of instruction, methods of mastery, and ways of determining the level of learning outcomes;

5. core educational programs are designed from a specific set of these educational modules;

6. criteria for determining the level of development of students' spatial imagination and methods for assessing it are developed.

Full implementation of these conditions guarantees the achievement of the expected results in developing students' spatial imagination in the subject of Descriptive Geometry and Engineering Graphics in higher education institutions.

In developing the spatial imagination of students in the Technological Education field, it is necessary to pay special attention to the selection of teaching methods and the thorough formation of methodology when organizing learning activities, especially practical classes. Therefore, E.M. Fazlulin, V.A. Ryabov, and O.A. Yakovuk consider one of the tasks facing university teachers to be the correct selection of teaching methods and the effective construction of methodology in organizing lessons. Consequently, the correct choice of teaching methods in teaching Descriptive Geometry and Engineering Graphics ensures the interrelation between goals and outcomes. For this reason, university instructors are required to pay particular attention to selecting them correctly.

The correct selection of teaching methods in teaching Descriptive Geometry and Engineering Graphics is carried out on the basis of the following: the general goals of instruction; the specific features and characteristics of the given academic subject; the aims and tasks pursued in teaching the subject, as well as the content of the learning material planned for each individual session; the amount of time allocated for studying the material; students' level of preparedness, psychological and psychophysiological indicators; the provision of the teaching process with educational, technical, and technological equipment (teaching aids, visual materials, technical, computer, and other material resources); and the teacher's level of preparedness and personal qualities.

According to the authors, the correct selection of teaching methods and the careful construction of methodology guarantee the achievement of the following results: fostering students' interest and motivation to thoroughly master the fundamentals of Descriptive Geometry and Engineering Graphics; increasing their learning and cognitive activity; ensuring that students acquire independent, critical, and creative thinking skills; improving the quality of teaching the fundamentals of this subject by students; and enhancing the effectiveness of teaching Descriptive Geometry and Engineering Graphics.

In higher education institutions, the process of developing students' spatial imagination can be organized on the basis of the following methodology:

1. Working curriculum.
2. Modular learning materials.
3. Test assignments to assess students' knowledge.
4. Practical tasks.
5. Learning cases.
6. Individual assignments.
7. Graphic tasks for independent work.
8. Educational-methodological handouts.
9. Glossary.
10. Presentation.
11. Engineering graphics software.

Below is a possible way to develop methodological guidelines for practical tasks.

One of the specific features of the academic subject "Descriptive Geometry and Engineering Graphics" taught at higher education institutions is that the process of developing, first and foremost, spatial imagination, as well as practical skills and abilities in future teachers of

Technological Education, is based on practical assignments. Therefore, during the research, attention was also paid to forming a set of practice-oriented tasks for the instructional modules. Practical assignments were given to pairs and small groups according to their level of complexity. In particular, students were given practical tasks for pair work within the modules “Projection Drawing” and “Machine-Building Drawing.”

It is well known that, as with all subjects, introducing a clear and scientifically grounded system of teaching and educational activities in the teaching of Descriptive Geometry and Engineering Graphics is of great importance. In preparing students for independent professional activity and lifelong learning, it is essential that they master drawing skills, since modern technological progress cannot be imagined without a deep and continuous knowledge of this subject. For this purpose, students must acquire the necessary skills and abilities in the process of being taught how to construct and draw graphics.

If, when teaching drawing, the teacher begins by shaping students’ graphic abilities and developing their spatial imagination, then at the initial stage (drawing simple geometric solids, studying types of lines, etc.) the students’ mental activity starts to develop. If the teaching process is organized in this way and the teacher directs all attention to teaching and reading drawings, the situation changes in a positive direction: from the very first lesson the student is required to engage in intensive thinking.

Observations show that, in accordance with the curricula of the Technological Education program, before starting systematic study of technical drawing, students should become familiar with the following:

- basic geometric shapes (plane and solid);
- constructing images of basic geometric bodies in the plane;
- methods of executing sketches and technical drawings, and the process of separating and preparing elementary parts of a sketch or technical drawing in accordance with specified dimensions;
- working with drawings using basic geometric constructions;
- determining the shape of all elements of a part and, by mentally combining these elements, forming a holistic idea of the part’s shape;
- reading all the conventions of a working drawing;
- paying attention to the conventional symbols that help determine the shape of individual elements of a part, such as diameter (Ø), radius (R), square (□), slope ( ), taper ( ), etc.

Thus, at the initial stage of teaching drawing, students must rely on the knowledge and skills they acquired during grades 1–9. However, taking into account that this knowledge is still insufficient, it is necessary to expand and deepen it starting from the very first lessons in drawing.

Research shows that various definitions of the concept of “reading a drawing” exist in the literature. For example, in the manual Chizmachilik (Technical Drawing) for students of pedagogical higher education institutions, authored by Professor G. A. Vladimirskiy (edited by Buravsev), it is noted that in an orthogonal (rectangular) projection system, the main indicators that help identify simple geometric shapes depicted in a drawing are specified. On page 87 of this manual it is stated that: “If, in a system of three projections, only straight-line segments are present in the drawing, then the object depicted has a polyhedral form; at the same time, the straight-line segments indicate either the lines of intersection of the faces, or, if the faces lie in the projecting planes, the projections of these faces.”

The ability to read a drawing can be formed by representing the spatial shape of an object using a conventional flat image and determining its dimensions, as well as all the information necessary for its manufacture and control. In this case, the process of reading a completed drawing can be conditionally divided into two completely independent stages, including presenting the geometric form of the object based on its image (Figure 1).

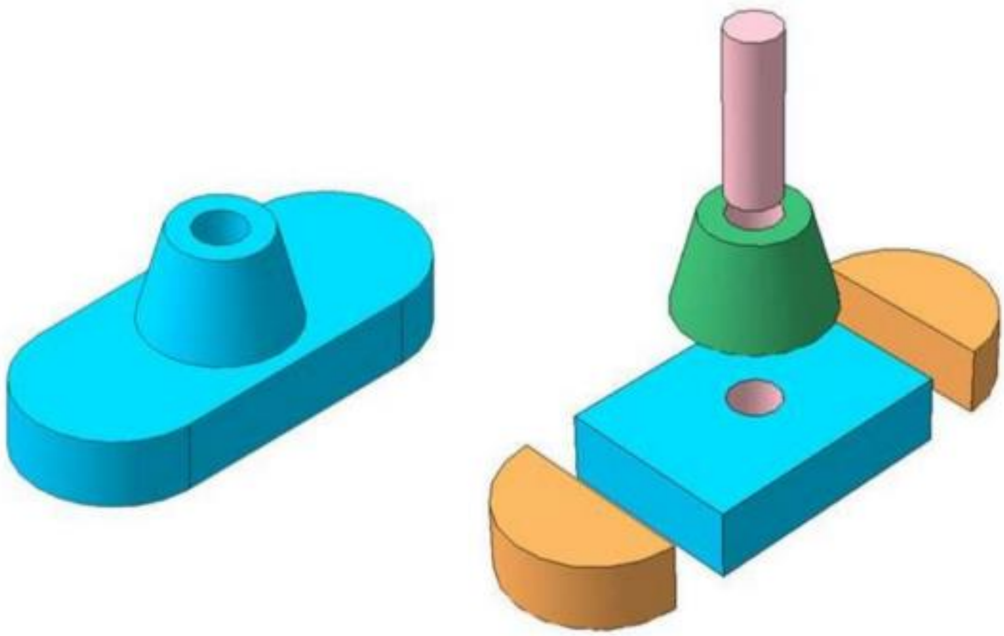

Figure 1.

Some researchers note that constructing an object's drawing from an existing drawing (or "reading" the geometric shape of an object) is the main difficulty for students. Therefore, it is necessary to develop certain abilities in students so that they can read the shapes of basic geometric solids, polygons in projection systems, and objects represented by drawings.

Before moving on to teaching students how to read a drawing, it is necessary to develop their ability for geometric analysis. In this process, learners must know the shape and structure of real geometric solids and models, as shown in Figure 2.

Polyhedra **Surfaces of revolution**

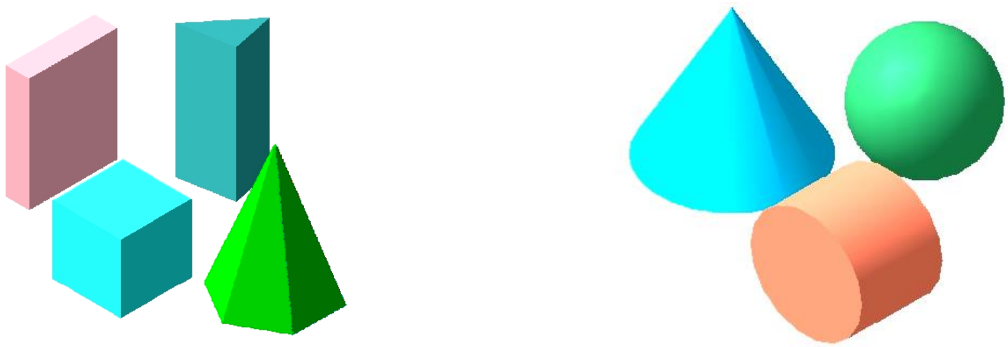

Figure 2

As psychologists have noted, at the initial stage of teaching students to read drawings, the formation of their spatial imagination requires visual teaching aids such as demonstrations, educational posters, models, and technical parts used in the process of teaching drawing. In this regard, let us consider the content of a series of exercises aimed at developing students' ability to analyze the geometric shapes of real objects.

The proposed exercises include the following tasks:

• identifying the essential and non-essential properties of basic geometric solids;

- analyzing the shape of basic geometric solids (based on models);

- analyzing the shape of parts formed by different combinations of basic geometric solids (based on models and machine parts);

- reconstructing the views and clear images of an object or part according to its description;

- writing a description of an object or part, and so on.

After performing such exercises, it becomes much easier to focus students' attention on studying the essential and non-essential properties of basic geometric solids. In our pedagogical observations, we study these properties as follows: the teacher shows the group everyday household objects and explains from which geometric solids they are composed and into which polyhedral elements they can be divided (Figure 3). In this task, the student performs a written analysis together with an analysis of the marked areas on the given visual representation.

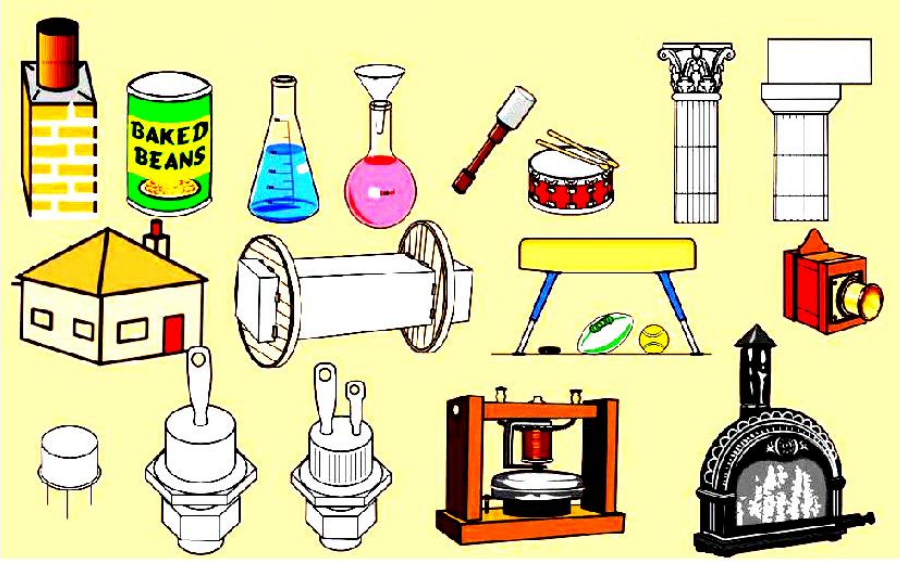

Figure 3

In addition, the teacher explains to students that any machine part or model is made up of a series of geometric solids; their shapes are formed by rotating figures such as triangles, circles, and rectangles, and demonstrates the process by which conical, cylindrical, spherical, and prismatic surfaces are generated.

At the same time, by asking students a series of questions, the teacher activates their mental activity and leads them to independently identify the essential and non-essential properties of geometric solids.

Under the guidance of the teacher, students study prisms, pyramids, cylinders, cones, and so on, and determine their essential and non-essential characteristics. Students must learn to distinguish the faces, edges, vertices, and bases of polyhedral solids. When analyzing the shapes of geometric solids, it is necessary to change their spatial position so that students can understand as early as possible that the shape of a geometric solid does not depend on its position in space.

To check the level at which students have mastered the new material, the teacher asks them several questions, such as:

1. How are a cube and a rectangular parallelepiped described? To which group do they belong (polyhedra or geometric solids)?

2. Analyze a regular right triangular prism and show that it has bases, vertices, edges, and faces.

After studying the basic geometric solids and their essential and non-essential properties, we move on to exercises in analyzing the geometric shape of parts. In this case, based on the orthogonal projections of the model given in Figure 4, its shape is analyzed by breaking it down into geometric solids.

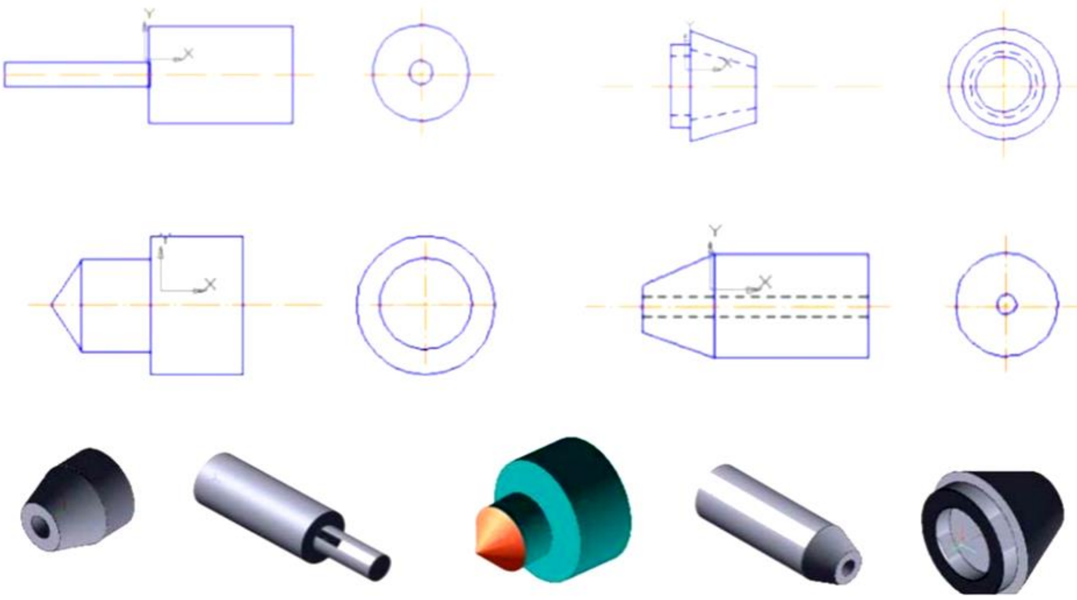

Figure 4

After students, under the teacher’s guidance, have completed a series of similar whole-class (frontal) exercises, it is possible to move on to individual assignments. For independent work, the teacher must prepare a set of models (parts) in an amount equal to the number of students in the group. For practical tasks, the geometric shape of the parts should be simple (consisting of 2–4 geometric solids). Only in this case will it become easier, in Descriptive Geometry and Engineering Graphics classes, to develop students’ spatial imagination through reading drawings.

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