Computer modeling in education for the development of students' research skills

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Abstract. The paper considers the need to develop some applied pedagogical issues of the general theory of modeling, as well as psychological and pedagogical problems solved by modeling in the learning process, in particular, in the formation of concepts, the interpretation of sign mathematical models and the solution of educational graphic problems, where modeling does not act as an additional method to the current verbal and logical method. The paper gives the examples of visualization in planimetry, the dynamics of proving the Pythagorean theorem by the method of equi partibility, the method of deformation of parts while preserving their areas and the method of cutting theory, as well as an example of an applied problem for three-dimensional modeling of the theoretical surface of a ship hull in a computer-aided design system KOMPAS-3D.

1 Introduction

Currently, there is a need to create a new information society in the higher education system, which will ensure the development of production in a new, digital format, thereby increasing the competitiveness of our country at the world level. Innovative information technologies occupy a special place in higher education in the formation of modern engineering competencies of marine specialists [1].

The introduction of information technologies into the educational process is becoming a global phenomenon defining new innovative approaches to education. The modern educational system should be focused on the development of professional and digital competencies among students, which will allow them successfully applying the knowledge, skills and abilities gained during training in accordance with the new requirements [2]. Currently, there are high requirements for training specialists. Students need to form a high level of professional knowledge, develop spatial and logical thinking, master a set of specialized graphic programs. Such skills are acquired by students of technical higher educational institutions in classes on descriptive geometry, engineering, and computer graphics. These disciplines are included in the study programs of technical specialties.

2 Materials and Methods

Modeling is a set of tasks and actions organized by a teacher and independently performed by students, resulting in a creative product. In order to understand the design and operation of the illustrated product, as well as to present their technical thoughts using a drawing, students must be able to read the drawing. Only students with a sufficient theoretical base of geometric knowledge of projection drawing will be able to solve these problems using computer modeling methods, which will allow shifting their thinking from abstract to real [3].

Computer modeling develops spatial representation and imagination, structural-geometric thinking, the ability to analyze, synthesize and transform spatial forms presented as drawings and models of specific spatial objects, allows modeling various objects, as well as gives the ability to move from a real object to its model and carry out the opposite process: from model to real object. At the same time, computer modeling is some link between science and production. The higher the level of computer modeling, the more effective the interaction of science with production [4].

The concept of modeling is multifaceted and includes a huge variety of modeling methods: from creating natural models (copies of real objects) to the derivation of mathematical formulas. A model is an object resulting from a simulation. It may not necessarily be a real object. It can be a mathematical formula, a graphic object, etc. However, it may well replace the original when it is studied and described.

With the advent of many graphic programs, such as AutoCad, Compass-3D, Solid Works, Autodesk Inventor, and others, it became possible to create geometric models of various objects, work with models of objects in 3D space, and experiment with them. The purpose of such systems was to overcome the problems associated with the use of physical models in the design process, such as obtaining complex forms of models with accurate dimensions, as well as the difficulty of extracting the necessary information from real models for their accurate reproduction [5–7].

The main directions in the development of mathematical and computer modeling are currently the problems such as the model-algorithm-program relationship or the drawing-algorithm-model relationship. A significant number of studies devoted to modeling in teaching mathematics or computer graphics belong more to experimental methods [9]. In practice, the modeling method as a separate educational task is considered much less often.

The actions to form a mathematical and computer concept and solve graphic problems constitute an

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interpretation that is carried out using modeling. The basis of this interpretation is the function of the model in mathematical and graphic language, the ability to reflect the processes of thinking of the subject and the ability to perceive the model. The learning process is aimed at developing the research skills of students using modern digital technologies, while the student moves from one level of thinking to the development of logical and spatial thinking, the ability to computer experiment. Since the model is considered as an object of study, its study gives us new information about this object. This means that the model is an intermediate link between theory and reality and is a means of interpretation both in the direction of concretization and in the direction of formalization. In one case, one model is clear when explaining the educational material, in the other case – another model. Modeling should act as a necessary means of solving graphic problems and be applied with a traditional learning approach. The actions to form a mathematical and computer concept and solve graphic problems constitute an interpretation that is carried out using modeling. The basis of this interpretation is the function of the model in mathematical and graphic language, the ability to reflect the processes of thinking of the subject and the ability to perceive the model. The learning process is aimed at developing the research skills of students using modern digital technologies, while the student moves from one level of thinking to the development of logical and spatial thinking, the ability to computer experiment. Since the model is considered as an object of study, its study gives us new information about this object. This means that the model is an intermediate link between theory and reality and is a means of interpretation both in the direction of concretization and in the direction of formalization. In one case, one model is clear when explaining the educational material, in the other case – another model. But each model already has the ability to build another model based on it. Then the explanation can be presented, and most often it happens, by a chain of models, where all models are combined by a main isomorphic relation. The same explanation, composed of a chain of models, is the interpretation of mathematical graphic models in their various forms– verbal, sign-mathematical and graphic forms. In this case, clarity acts as a property that allows moving from one model to another, from one level of thinking to another.

3 Results and Discussion

We believe that when teaching students using computer modeling, it is appropriate to use an approach related to the development of students' ability to analyze and build work according to the new conditions of the task. The analysis of the stages of building computer models made it possible to distinguish the competencies of students:

- need to set a research goal, analyze available information, create a formalized description of the task;
- ability to find patterns, possible repetitions, choose the best solution tool when building a problem;
- ability to be creative in solving a problem, willingness to use the knowledge of various educational disciplines in solving problems;
- ability to adequately assess the result of modeling, find possible ways to improve the designed solution algorithm.

The research perspectives include the development of virtual models (better dynamic visualization) of mathematical and geometric three-dimensional models. For example, the continuation of dynamic visualization of problems and theorems of planimetry is a natural transition to modeling spatial mathematical objects and processes (proofs and constructions).

As an example of visualization in planimetry, the study shows the dynamics of proving the Pythagorean theorem by the equivalence method (Fig. 1), by the method of deformation of parts with preservation of their areas (Fig. 2) and by the method of cutting theory (converting two rectangles or squares into an equal square) (Fig. 3).

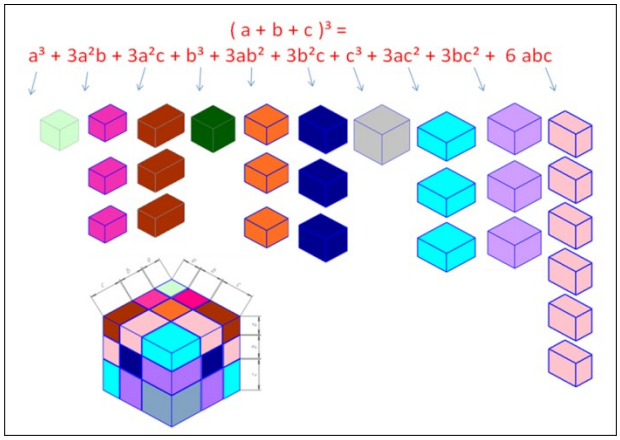

Fig. 1. Example of computer modeling of a formula.

Considering cases when concepts are incompletely formed, we find that examples that include these concepts are mainly solved, while problems– not. The facts that when solving a problem, a student is guided by the rules of calculation, an algorithm, and the structure of the concept is information noise, and to solve the problem, a student needs to have a decisive structure of the concept in mind. In the example, the student is given a sign model in its finished form, and in the task such a model has yet to be derived from the subject situation.

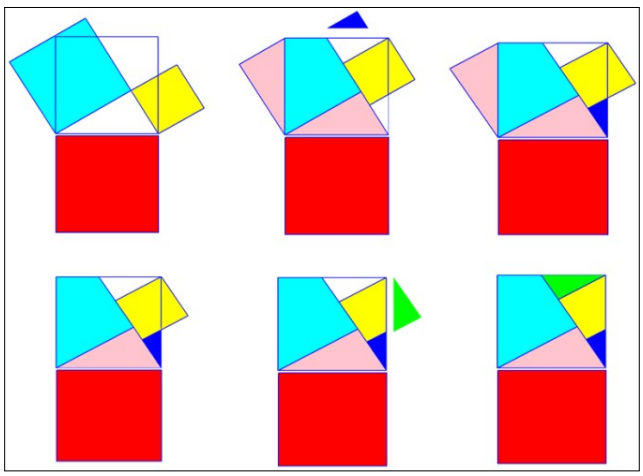

Fig. 2. Dynamics of the Pythagorean theorem proof.

The traditional approach to the formation of concepts, based mainly on the verbal method, in which formally memorized rules are given without interpretation and explanation, without passing substantive, effective and figurative-graphic forms of mental actions, does not provide the formation of full concepts. The modern teaching of the ability to solve problems includes two ways: the path of obtaining knowledge in general and the path of reasoning in this problem.

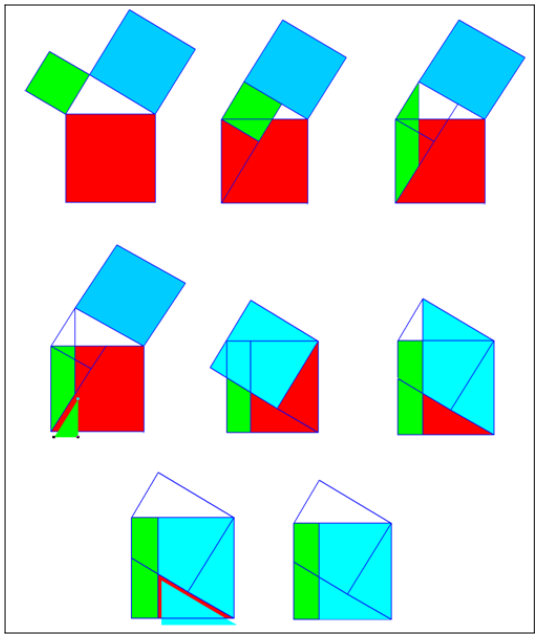

Fig. 3. Method of deformation of parts with preservation of their areas.

Geometric modeling has changed dramatically in recent decades. There was a qualitative leap in the development of models, their creation and use of model-based research methods, in the methods of analysis and presentation of modeling results. The use of volumetric technologies make it possible to obtain a realistic three-dimensional image, which is more convenient to perceive (Fig. 4).

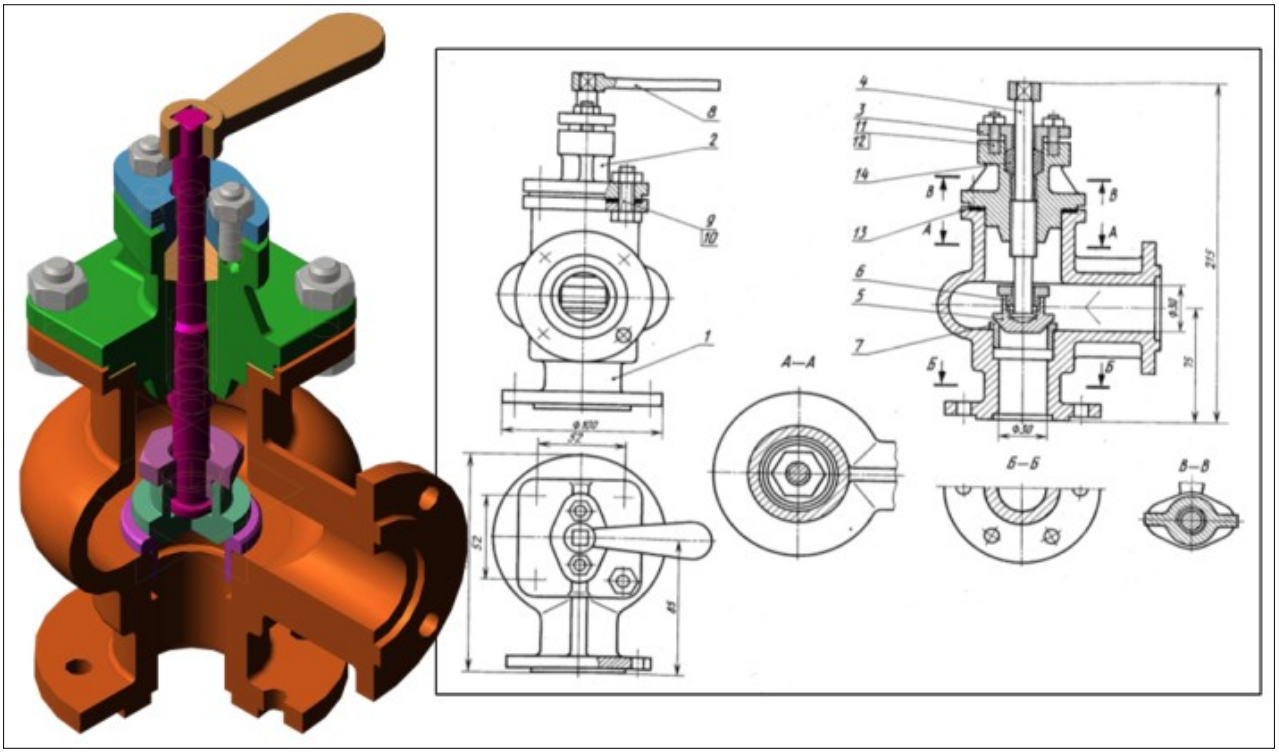

Fig. 4. Example of computer modeling and assembly of ship valves.

CAD Compass 3D has the widest possibilities for modeling surfaces of a high degree of complexity in the engineering field when developing models of mechanisms and machines. An example of building a model of the hull surface using the control sections of the vessel with planes repeating the shape of waterlines is presented, which makes it possible to practically solve the problem of geometric modeling and study complex framework surfaces based on universal CAD system (Fig. 5).

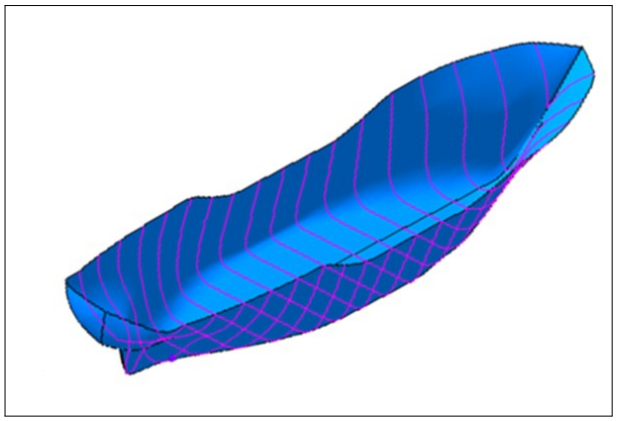

Fig. 5. Example of computer modeling of the hull surface according to cross sections.

4 Conclusion

Today, computer modeling is reaching a qualitatively new level– the level of three-dimensional geometric modeling. The use of computer solid 3D modeling in teaching graphic disciplines allows visualizing an object, creating its image, and using color. Thus, the use of modern digital technologies in learning makes it possible for students to most fully present the studied object, to identify all its geometric shapes, parameters and interaction with other models. The ability to analyze a complex drawing, mentally disassemble an object of complex geometric shape into simple component geometries allows easily switching from 2D models (flat drawings) to three-dimensional models and vice versa, which greatly simplifies the process of drawing editing.

The need to include modeling tasks in the learning process makes different interpretation of some fundamental modeling concepts inevitable. The tasks discussed in the work belong to the group of problem-based learning tasks, which are created for the student-computer tandem, designed not only to develop the student's thinking, but also to contribute a positive motivation to the desire to learn and study new things, which is aimed at achieving the following goals:

1) to develop logical and spatial thinking, the ability to computer experiment, the ability to make independent decisions;
2) to develop research skills and abilities, as well as interest in graphic creativity and modeling;
3) to form the understanding of the importance of computer modeling in the development of civilization and modern society;
4) to form the ability to control the process and results of training activities;
5) to develop the ability to perceive three-dimensional objects, tasks, solutions, programs;
6) to develop the understanding of computer modeling, creating the conditions for gaining initial experience in the modeling environment.

Computer graphics taught at a maritime university open up new opportunities for mastering such modern methods of scientific knowledge as formalization, modeling, computer experiment, etc. Computer modeling introduces new types of educational activities into the learning process, which in modern conditions are of a general scientific and general intellectual nature.

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