MODELING AS THE MAIN WAY OF COGNITION

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Abstract. *This article examines modeling as one of the main and most effective ways of cognition. Modeling enables the representation of complex objects, processes, and phenomena in a simplified and structured form, which facilitates deeper understanding, analysis, and prediction. The paper discusses the theoretical foundations of modeling and highlights its significance in scientific research, education, technology, and social sciences. Various types of models and their role in the cognitive process are analyzed, demonstrating how modeling contributes to the development of systematic thinking and knowledge acquisition.*

Keywords: *modeling, cognition, cognitive process, scientific research, model, abstraction, systems approach.*

Introduction

Modeling is currently attracting close attention and has received unusually wide application in many fields of knowledge: from philosophical and other humanitarian branches of knowledge to nuclear physics and other branches of physics, from problems of radio engineering and electrical engineering to problems of mechanics, physiology and biology, etc. It has become:

a) a general scientific, highly effective tool of cognition,

b) the method of forecasting engineering and design developments;

c) the method of machine simulation of long-term programs and plans in the field of economics, analysis and evaluation of various options for responsible decisions and the consequences of their implementation.

“A model is understood as a mentally imagined or materially realized system that displays and reproduces an object in such a way that its study provides new information about this object.” [2].

A model is a system, the study of which serves as a means to obtain information about another system. [1].

Modeling is the main way we learn about ourselves and the world around us. Defining the epistemological role of modeling, we note the variety of models in science and technology. The object being modeled is called the original, and the modeler is called the model. Models are classified based on the most significant features of objects. These signs are:

1) the law of functioning and the characteristic features of expressing the properties and relationships of the original;

2) the grounds for converting the properties and relationships of the model into the properties and relationships of the original.

Models can be divided according to the first feature into logical (according to the laws of logic in human consciousness) and material (according to the objective laws of nature) models. In turn, logical models are divided into figurative symbolic and figurative-symbolic (mixed) models. Material models are divided into functional, geometric, and functional–geometric models. Functional and functional-geometric models, depending on the original, are divided into physical

and formal ones. According to the second feature, conditional (based on basic conditions or agreements), analog (based on basic conclusions by analogy, continuous) and mathematical (mathematical methods of expression) models are distinguished.

Mathematical models can be distinguished from computational ones (mathematical representation of formulas, graphs, algorithms, etc.) and corresponding models (mathematical dependencies). Similar models are distinguished from the corresponding ones (proportionality of variables to the corresponding variables of the original). Such models can be logical and material. Such material models are divided into analog (continuous), digital (discrete), and analog-to-digital (combined and hybrid) models.

In general, the modeling process consists of the following steps::

1. Setting the task and determining the properties of the original to be investigated.

2 A statement of the difficulty or impossibility of researching the original in kind.

3. The choice of a model that captures the essential properties of the original well enough and is easily amenable to research.

4. Study the model in accordance with the task.

5 Transfer of the results of the model research to the original.

6 Checking these results.

The main tasks are: firstly, the selection of models and secondly, the transfer of the results of the model research to the original. Historical development of modeling. Historically, the first models as substitutes for some objects were undoubtedly symbolic conditional models. Or there were linguistic signs that naturally arose in the course of human development and gradually formed a spoken language.

The next stage in the development of modeling can be considered the emergence of symbolic numerical designations. Information about the results of the account was initially preserved in the form of notches. The gradual improvement of this method has led to the representation of numbers in the form of digits as a system of signs. It can be assumed that the notches were the prototype of the Roman numerals I, II, III, V, X.

The further development of sign models is associated with the emergence of writing mathematical symbols. The most ancient written texts currently known date back to about 2000 BC (Egypt and Babylon). There is reason to believe that the Babylonians already used the concept of the similarity of right triangles. Modeling was significantly developed in ancient Greece in the V-III centuries BC. A geometric model of the solar system was created, the physician Hippocrates used his physical analogous model, the bull's eye, to study the human eye, and the mathematician Euclid created the doctrine of geometric similarity. As mechanical production, shipbuilding, urban planning, etc. develop and strengthen, it is increasingly found that the geometric similarity of physically homogeneous objects is insufficient to predict the properties of large objects based on the properties of smaller objects.

The first step in the development of the theory of similarity in physical modeling was made by I. Newton (1643-1727), who formulated the condition for the similarity of mechanical phenomena. Further development took place for a long time by defining particular similarity conditions for phenomena of only a certain physical nature – the work of I.P.Kulibin (1735-1818) and L. Euler (1707-1783) in the field of structural mechanics, V.L.Kirpichev (1845-1913) in the field of elasticity, etc. Finally, in 1909-1914, N.E.Zhukovsky, D.Releyev, and F. Buckingham formulated a theorem that allowed them to establish conditions for the similarity of phenomena of physical nature.

In parallel, there was the development of logical modeling in a symbolic form, primarily the development of mathematics. At the end of the 16th century, D. Neper (1550-1617) invented logarithms. At the end of the 17th century, I. Newton and G. Leibniz (1646-1716) created differential calculus. Numerical methods for solving various problems are being developed. The first computing devices include the abacus (XV-XVI c.), the slide rule (early XVII c.). For a long time, computing devices were exclusively mechanical – an arithmometer, calculating and solving mechanisms, etc. And only in the 30s of our century (XX century.) begins the development of electronic analog and digital computing devices.

And the first generalizations of two directions of material modeling:

a) physical;

b) formal calculations using computing devices were made by V.A. Venikov (1949) and L.I. Gutenmacher (1949), and then further developed by I.M.Petelbaum (1959), A.M.Suchilin (1964), A.M.Alabuzhev (1968). Philosophical concepts of the main issues of modeling are reflected V.A.Stoff, I.B.Novikov, N.A.Uemov, and others.

The main aspect is not learning the rules, but the process of thinking itself. The student chooses the behavior strategy of the model himself (for example, the short task condition is a model of a text task), tries to find out what will happen as a result of his actions (solving the problem), based on his experience, draws a conclusion about the significance of the results obtained (the answer to the problem). It is well known that the language of information and logical models is universal, so mastering it makes the learning process of mathematics more meaningful.

The technology of teaching information modeling can be based on the method of active reflection. This method determines both the main learners of learning (teacher-student) by implementing a personality-oriented model currently being developed in a number of psychological, pedagogical and methodological studies, as well as the sequence of informing operations, explaining prescriptions, setting tasks and executing computer technologies to solve it.

The method of active reflection involves the activation of the student's mental and creative activity and the expansion of independence of choice in the process of teaching mathematics. In almost all sciences, the construction and execution of models is a powerful tool of cognition. When solving any problem, the main role is played by experiment and model, as well as analysis of the results obtained. The model provides a correctly set experiment by refining the model. The experiment has two directions: processing the results and planning the experiment.

The reliability of the model is achieved through observation and logically correct data processing. When building a model, a problem arises – the importance and role of the teacher in this process. The solution to this problem involves the use of a number of methodological models that define the general activities of a mathematics teacher.

1. Using concrete examples from world culture, the value of mathematical knowledge should be shown and revealed.

2. The use of science in society should be a means of connecting mathematical science with universal culture in the process of teaching mathematics.

3. In order for students to understand the cultural and therefore personal value of mathematical education, the content of the course must undergo significant changes.

4. The implementation of a holistic approach in teaching mathematics involves the construction of an optimal course option.

5. Teacher-student dialogue The mathematics issues under consideration are discussed on equal terms and are worked out in principle. A unified position reflecting the modern interpretation of the issue.

6. The dialogue that the student conducts with himself. It is born in the course of emotional perception and awareness of mathematical facts.

People tend to explore the world on models. When starting to study a scientific discipline (mathematics), we first get acquainted with the system of assumptions adopted for this discipline: which properties or connections of the studied objects and phenomena are essential for this discipline, and which are not.

When building any model, we always sacrifice something, refuse (abstract) from considering something that is not essential for the purposes of this model. The highest form of abstraction is mathematical abstraction. It allows you to forget about the nature of the modeled objects and connections during logical reasoning. All mathematical objects have the same logical nature. They are connected by logical connections and interact according to the rules of mathematics. This allows us to introduce a uniform universal formalization system for studying different processes and phenomena.

We will give the basic definitions and concepts for formalizing the model of the subject of mathematics. The information method is the result of the interaction of data and information methods, considered in the context of this interaction. The most important, from the point of view of management, are the following six properties of information: objectivity, completeness, reliability, adequacy, relevance, accessibility. Modeling is an information method consisting in the logical closure of an open system in order to limit the number of its possible states and the relationships between its elements in order to consider them exhaustively.

Model. The concept of the word "Model".

1. A model is a sample of a product, as well as a sample for making something.
2. Reduced reproduction of something.
3. Type and brand of construction.

Since we have compared management with science, it is necessary to recall such a widespread and effective scientific method as modeling. A model is a system specially designed for research that reflects the basic properties of the object under study. It recreates the real situation in an artificial way for studying.

The word "model" comes from Latin. Modus is a copy, a sample, an outline. These are, for example, geographical maps, diagrams of mechanisms and electronic devices, structural formulas in chemistry, etc. In general, any simulation system that replaces the object under study and facilitates the search for solutions to scientific, technical, economic or any other problem can be considered a model. The model usually simplifies, coarsens the real object, frees it from minor details that only obscure the essence of the matter.

People have long used models to study real objects and phenomena. In ancient times, for example, future irrigation facilities were imitated in this way. If the model differs from the original only in size, and the processes occurring in them are of the same nature, then such modeling is called physical, a scaled–down copy of an airplane in a wind tunnel, dam or bridge in an artificial water stream are examples of such models. When modeling is carried out using a process of a different nature, it is a method of analogy. Thus, the flow of liquid through complex hydraulic structures can be replaced by electric current in a specially assembled conductor circuit, and vice versa, the behavior of electrical circuits is sometimes studied using a hydraulic model. This type

of research has become widespread, and the special devices used in them are called analog devices, which include analog computers.

But perhaps we are most interested in a different type of modeling, when a set of mathematical expressions describe the behavior of the object under study. Such models make it possible to identify the most significant relationships and dependencies between the elements in the system under study, and help to understand the various aspects of the problem to be solved. We are talking about an accurate description of the most diverse processes and phenomena that one has to deal with in all areas of human activity. Considering the possible solutions on paper, it is relatively easy to choose the optimal one. No wonder they say that many discoveries were born on the tip of a pen. However, we have mentioned more about paper here for the sake of a red word, since you cannot sort out many options "manually", and some complex mathematical dependencies on paper turn out to be intractable. But now we have computers, and they can solve almost any equation.

The main value of mathematical models is that they allow you to create artificial realities and predict the consequences of certain actions or events, and this is very important, in particular, for production planning and management. By resorting to modeling, we are waiting for a reasonable answer to the question: what happens if we act one way or another?

The use of models as substitutes for the studied real phenomena is now one of the main signs of a scientific approach both in cognition of reality and in practical activity. A characteristic feature of this method, as we have already noted, is that at a certain stage of cognition, instead of a real phenomenon, we consider its idealized model, which we explore. But such a replacement is advisable only if the model correctly reflects the properties of the studied reality from the side we are interested in and at the same time is simpler and more convenient for research than the simulated real object. And just in connection with the expansion of the scope of computers, the role and importance of mathematical models for representing real objects and situations have now increased.

Over the millennia of its existence, mathematics has come a long and difficult way, turning from a primitive ability to count into a vast and extensive scientific branch. People appreciated the importance of mathematics in ancient times, realizing that this science provides not only computational methods, but also serves as a universal key to penetrate into the essence of the fundamental laws of reality being studied.

Mathematics has chosen its own language – very precise, economical and at the same time universal, which has proved effective in a wide variety of fields of knowledge. Mathematical symbols make information recording compact and convenient for subsequent processing. Mathematics introduces the concepts of quantity, precision, clarity, and evidence into any field. Most applied sciences now "speak" mathematical language.

Always occupying the most honorable place among the sciences, mathematics, until recently, found limited use in solving economic problems. It is only with the advent of computers that mathematics becomes an everyday working tool for planners, economists, engineers, agronomists, livestock technicians, and other professionals involved in the field of material production.

Highly qualified mathematicians at institutes, using the latest scientific achievements, develop a mathematical model for solving a specific practical problem, after that they create a modeling algorithm and a standard computer program with which any practitioner can solve the same problem for his household. He does not need to thoroughly know the equations that form a

mathematical model, nor the methods for solving them. What he has to do is insert a program into the computer and enter into it the necessary data about the actual production conditions.

Conclusion: In conclusion, modeling plays a crucial role in cognition as a universal and efficient method of understanding reality. It allows complex phenomena to be perceived, analyzed, and interpreted through simplified representations. The use of modeling enhances cognitive activity, supports scientific inquiry, and improves problem-solving across various fields. Therefore, the effective application of modeling significantly contributes to the advancement of knowledge and the accuracy of scientific outcomes.

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