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FEATURES AND EFFECTIVENESS OF THE MODELING METHOD

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Abstract. *The modeling method is considered an effective and innovative approach in modern education, enabling the representation, analysis, and understanding of complex processes, phenomena, and systems through simplified models. This method enhances students' cognitive activity, analytical thinking, and problem-solving skills by allowing them to simulate real-life situations in a controlled learning environment. The use of modeling promotes deeper comprehension of theoretical concepts and facilitates the integration of theory with practice. Furthermore, it encourages creativity, самостоятельность, and research-oriented learning among students. The effectiveness of the modeling method is обусловлена its ability to provide visual, interactive, and экспериментально oriented learning experiences. However, successful implementation requires appropriate methodological support, technological resources, and the readiness of both teachers and learners. Thus, the modeling method plays a significant role in improving the quality and efficiency of the educational process in higher education institutions.*

Keywords: *modeling method, educational technology, higher education, learning effectiveness, simulation, cognitive activity, problem-solving, innovative teaching, interactive learning, research skills*

In modern science and education, the modeling method plays a crucial role in understanding complex systems and processes that cannot be directly observed or

experimentally studied in real conditions. Modeling provides a simplified representation of reality that preserves the most significant features of the original object. This approach is widely used in engineering, economics, psychology, pedagogy, and information technology [1].

The increasing complexity of modern systems has made modeling an indispensable scientific tool for prediction, analysis, and optimization.

Main Part. Concept and Essence of the Modeling Method. The modeling method is a research approach based on the creation and study of simplified copies (models) of real objects or processes. It allows researchers to analyze systems that are difficult, expensive, or dangerous to study directly [2].

A model reproduces not the entire object but only its essential properties, relationships, and structures, making analysis more manageable and effective.

Types of Modeling. Modeling can be classified into the following main types:

- **Physical (material) modeling:** reproduction of real objects while preserving their physical properties (e.g., technical prototypes, aircraft models).
- **Symbolic (abstract) modeling:** representation through mathematical formulas, graphs, and diagrams.
- **Computer (simulation) modeling:** use of algorithms and software systems to imitate real processes in a virtual environment.

Algorithm of the Modeling Process. The modeling process consists of several key stages:

1. **Goal setting** – defining the purpose of the study;
2. **Model construction** – identifying essential characteristics of the original system;
3. **Experimentation** – performing operations on the model to obtain data;
4. **Analysis of results** – interpreting outcomes and validating the model's accuracy [3].

This structured approach ensures systematic and reliable research outcomes.

Effectiveness of the Modeling Method:

The effectiveness of the modeling method is determined by several factors:

- it allows the study of complex and large-scale systems;
- it reduces financial and time costs compared to real experiments;
- it improves visualization and understanding of abstract concepts;
- it supports prediction and decision-making processes;
- it develops students' analytical, critical thinking, and research skills [4].

In education, modeling is especially valuable because it integrates theoretical knowledge with practical application, thereby increasing learning efficiency and student engagement.

Discussion. Despite its advantages, the modeling method requires careful design and validation. The accuracy of results depends on how well the model reflects the essential properties of the real system. Therefore, researchers must ensure the adequacy and reliability of models before applying conclusions to real-world situations [5].

In addition, modern computer technologies have significantly expanded the possibilities of modeling, making it more interactive, dynamic, and widely applicable.

Main Types of Research:

- **Physical (material) modeling:** Reproduction of an object while preserving its physical nature (e.g., an aircraft model).
- **Symbolic (abstract) modeling:** Description using formulas, graphs, or diagrams (e.g., a mathematical model).
- **Computer modeling:** Use of algorithms and software to simulate processes (virtual modeling).

Key Stages (Algorithm):

1. **Goal setting:** Determining what exactly needs to be understood.
2. **Model development:** Identifying the essential characteristics of the original object.
3. **Experimentation:** Performing manipulations with the model to obtain data.
4. **Analysis of results:** Transferring the obtained knowledge to the real object (validating adequacy) [6].

Modeling is widely used in science, engineering, economics, and psychology for forecasting and optimization.

Since the modeling method is particularly specific to engineering psychology, it deserves closer consideration. As noted, it is important to take into account the specifics of human interaction with technology, expressed in the дистанционный nature of working with control objects and the use of representational models. These features are fundamental and define the specificity of the method. Such methods include modeling operator activity within the "human–machine" system [7].

B. A. Smirnov defined the essence of the modeling method as the study of activity and, on this basis, the construction of psychological, mathematical, or statistical models. It is important that models do not reproduce the object in full but only its most significant elements, relationships, and connections. This makes it easier to isolate and analyze complex systems.

Types of Modeling of Operator Activity. According to B. A. Smirnov, several types of modeling of operator activity can be distinguished:

Psychological Modeling. Psychological modeling involves replacing real activity with a modified version (using simulators, mock-ups, or test stands). Two main types can be identified:

1. External reproduction — imitation of the operator's work and workplace;
2. Reproduction of key aspects of activity that may not resemble the real process externally. For example, in modeling group activity using a homeostatic

method: individuals are placed in separate shower cabins and must adjust the water so that everyone is satisfied. Although this does not visually resemble real operator work, it effectively models complex interpersonal interactions within a team [8].

Mathematical Modeling. This involves studying activity based on mathematical models (formulas, inequalities, patterns), particularly when such models correspond to real work processes.

Statistical (Simulation) Modeling. Statistical modeling, also known as simulation modeling, represents the imitation of operator activity using computers. It takes into account various influencing factors, including the prediction of random variables.

Statistical (simulation) modeling is a method of scientific research in which real processes or systems are reproduced using mathematical algorithms, probability theory, and computer technologies. It is designed to imitate the behavior of complex systems under different conditions, taking into account random factors and uncertainty.

Unlike deterministic models, statistical modeling does not provide a single exact result. Instead, it generates a range of possible outcomes based on probability distributions and stochastic processes. This makes it especially useful for studying systems where randomness plays a key role.

The main idea of statistical modeling is to build a virtual representation of a real system and then conduct repeated experiments (simulations) to observe its behavior. These simulations help researchers identify patterns, trends, and probable outcomes without direct experimentation on the real object.

For example, instead of testing an educational system in real classrooms for years, researchers can simulate student behavior, learning outcomes, and teacher interactions using computer-based models.

Key Features. Statistical modeling has several important characteristics:

- Incorporation of randomness: It considers random variables and uncertain factors.
- Repetition of experiments: Simulations are performed many times to obtain reliable statistical results.
- Probability-based outcomes: Results are expressed in terms of likelihood rather than certainty.
- Computer-based implementation: Modern statistical modeling is mainly performed using specialized software and algorithms.
- Flexibility: It can be applied to various fields such as education, engineering, economics, psychology, and management.

Process of Statistical (Simulation) Modeling. The modeling process usually includes the following stages:

1. Problem definition: identifying the system or process to be studied.
2. Model construction: creating a mathematical or algorithmic representation of the system.
3. Identification of variables: defining random and fixed parameters.
4. Simulation execution: running computer experiments multiple times.
5. Data collection: gathering results from simulations.
6. Statistical analysis: calculating averages, probabilities, variances, and trends.
7. Interpretation: drawing conclusions and making predictions about real-world behavior.

Applications. Statistical simulation modeling is widely used in:

- Engineering: testing system reliability and performance
- Economics: forecasting market behavior and risk analysis
- Education: analyzing learning outcomes and teaching effectiveness
- Medicine: simulating disease spread and treatment effects
- Transport systems: optimizing traffic flow and logistics

- Psychology: modeling human decision-making and behavior patterns

Advantages:

- Allows study of complex systems without real-world risk
- Reduces cost and time of experiments
- Helps in predicting uncertain future events
- Supports decision-making under uncertainty
- Provides detailed analysis of system behavior under different scenarios

Limitations:

- Requires accurate input data for reliable results
- May involve high computational cost
- Results depend on quality of the model assumptions
- Requires strong statistical and programming skills

Statistical (simulation) modeling is a powerful research tool for analyzing complex and uncertain systems. By combining probability theory, mathematics, and computer technology, it enables researchers to predict outcomes, test scenarios, and improve decision-making processes. Its importance is continuously growing in modern science, education, and industry due to the increasing complexity of real-world systems.

Conclusion. The modeling method is a powerful scientific and educational tool that enables effective analysis and understanding of complex systems. Its flexibility, efficiency, and wide applicability make it an essential component of modern research and higher education. The integration of physical, mathematical, and computer modeling methods enhances scientific investigation and contributes to the development of innovative thinking and professional competencies.

A research method is a way of studying objects and processes or an attempt to investigate them by creating and analyzing their simplified representations (models). It allows researchers to analyze systems that are difficult, expensive, or dangerous

to study directly. The key stages include defining the problem, creating a model, conducting experiments, and analyzing the obtained results.

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