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MATHEMATICAL MODELLING IN EFFECTIVE PEDAGOGY

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Abstract. *The main advantage of mathematical modeling in education is the ability to objectively analyze complex systems that include the interaction of students, teachers, educational institutions and external factors. The use of mathematical modeling allows not only to identify patterns and predict results, but also to make optimal decisions at all levels of the educational system.*

The article presents the results of a study of the use of mathematical modelling in effective education, in particular, the relevance and importance of mathematical modelling both for applied problems of pedagogy and in modern pedagogical scientific and practical research is proven; appropriate cybernetic methods and algorithms of mathematical modelling for effective pedagogy are determined; proposed main areas of application of mathematical modelling in pedagogy; successful cases were analyzed.

Key words: *pedagogy, formalization, mathematical modelling*

Introduction.

Mathematical modeling in education is a method of formalizing, analyzing and optimizing educational processes using mathematical methods and tools. In the context of digital transformation and increasing data volumes, it is becoming a key element for solving problems of managing educational systems, individualizing learning and assessing its effectiveness.

The main advantage of mathematical modeling in education is the ability to objectively analyze complex systems that include the interaction of students, teachers, educational institutions and external factors. The use of mathematical modeling allows not only to identify patterns and predict results, but also to make optimal decisions at all levels of the educational system.

Mathematical modeling in pedagogy is a research method aimed at formalizing, analyzing and optimizing educational processes using mathematical methods. In the context of rapid technological development, increasing complexity of the educational environment and increasing requirements for the quality of education, mathematical modeling is becoming an important tool for analyzing the effectiveness of educational systems, forecasting their development and making decisions.

Main part.

Models in pedagogy allow us to study various aspects of educational activities: from the individual learning process to the systemic analysis of educational institutions and national education systems. They help to identify patterns, make forecasts and optimize teaching methods.

The role of mathematical modeling in pedagogy:

1. Formalization of educational processes.

One of the key tasks of pedagogy is to study the patterns of learning and education. However, these processes are often complex, multi-component and uncertain. Mathematical modeling allows us to present them in the form of formalized structures

that are easier to analyze, interpret and improve. For example: learning process models can take into account the amount of time spent on studying the material, the level of preparation of students and the complexity of tasks; knowledge acquisition models (for example, the Piaget learning model or adaptive knowledge assessment algorithms) allow us to predict how students will perceive and remember information depending on the learning conditions.

2. Optimization of educational systems.

Mathematical modeling is used to optimize various aspects of educational systems:

- The schedule of the educational process. Class scheduling problems can be solved using optimization methods such as linear programming or heuristic algorithms.
- Resource allocation. Models can be used to determine how to most efficiently distribute educational materials, teachers, and infrastructure to improve learning.

3. Evaluating the effectiveness of educational strategies

Modeling allows you to quantify the results of implementing different pedagogical approaches and technologies. For example: models for comparative analysis of traditional and digital learning can show which technologies are more effective in specific settings; learning management systems (LMS) such as Moodle use mathematical algorithms to analyze student performance and recommend ways to improve learning.

4. Forecasting and management of educational processes.

Predictive models help predict how changes in the educational environment will affect academic performance and social aspects. For example: demographic models help predict the needs of educational institutions; models for managing student flows at universities allow you to plan the load on infrastructure and personnel.

Examples of mathematical modeling in pedagogy*:*

1. Models of knowledge acquisition:
   - Hebb model. Based on the theory of associative learning, where repeated interaction strengthens the connection between neurons.
   - Ebbinghaus model. Predicts the processes of memorization and forgetting by analyzing the forgetting curve.
2. Socio-pedagogical models:
   - Analysis of student-teacher interaction using game theory.
   - Study of group dynamics of students using system models.
3. Economic models in education:
   - Analysis of training costs and calculation of the economic efficiency of educational programs.
4. Models for assessing the quality of education:
   - Use of statistical models for analyzing academic performance, such as regression analysis and data clustering.

Relevant tools and approaches to mathematical modeling in pedagogy:

- Statistical methods: used to analyze data on academic performance, attendance, and level of knowledge of students.
- Optimization methods: used to allocate resources, plan the educational process and schedule classes.

- Machine learning: used to create adaptive learning systems and predict educational outcomes.

- Computer simulations: allow modeling complex processes, such as the management of educational institutions or the dynamics of large groups of students.

Advantages of mathematical modeling in pedagogy:

1. Objectivity. Models are based on data and mathematical calculations, which reduces the influence of subjective factors.

2. Resource savings. Analyzing alternative strategies and approaches using modeling helps avoid unnecessary costs.

3. Forecasting. Models allow you to assess the long-term consequences of educational changes and make more informed decisions.

Considering the above, the author emphasizes the importance of acquiring relevant competencies in mathematical modeling within the curricula not only of pedagogical educational specialties [4, 5, 6], but also for other humanitarian educational programs and plans, which is confirmed in publications [7, 8].

Summary and conclusions.

Mathematical modeling plays an important role in the educational sphere, providing tools for analyzing, forecasting and optimizing educational processes. It helps to improve the efficiency of educational institution management, individualize learning and improve the quality of educational services.

With the development of technology and the increase in data volume, mathematical modeling will become an even more important tool in the education system, opening up new opportunities for analyzing and improving educational processes at all levels.

Mathematical modeling plays an important role in pedagogy, providing tools for analyzing, forecasting and optimizing educational processes. It helps educational institutions adapt to modern challenges, improve the quality of education and use resources efficiently. In the context of digital transformation and the growth of data volume, mathematical modeling is becoming an indispensable tool for the development of pedagogical science and practice.

Discussion.

As a promising direction of his future research, the author puts forward the following debatable thesis: hybrid mathematical modeling (a methodological approach that combines various mathematical methods and models to solve complex multi-component problems [9]) in pedagogy, as a multi-component interdisciplinary field, will be increasingly relevant and in demand. Since modern educational processes include many factors, such as the cognitive abilities of students, psychological and pedagogical aspects, social conditions, the influence of digital technologies, the ad-hoc influence of external and often force majeure crisis factors (conflicts and military actions, epidemics, natural disasters, etc.). It is hybrid modeling that allows us to try to take into account these ad-hoc influences by combining traditional mathematical methods, statistics, machine learning and system analysis of structured, semi-structured and even UNstructured Big Data [10].

In other words, hybrid mathematical modeling is a promising approach to the analysis and management of educational processes. It allows combining the power of

traditional mathematical methods with the capabilities of modern technologies, such as machine learning and artificial intelligence [11]. This is especially important in the context of dynamically developing educational systems and increasing volumes of data. This approach not only increases the accuracy of models, but also allows them to be adapted to changing conditions, creating the possibility of a deeper understanding of educational processes, predicting their development and optimizing teaching methods.

In pedagogy, hybrid modeling contributes to the personalization of learning, increasing the effectiveness of educational programs and making informed decisions based on data. The future of pedagogical science and practice will largely depend on the development and implementation of such interdisciplinary hybrid approaches that provide a deeper understanding and optimization of educational processes, especially with the comprehensive and systematic use of cloud technologies [12, 13] (taking into account epidemic and military crises).

It is this promising direction of the author's future scientific research that will be reflected in future publications.

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