Дидактический процесс преподавания высшей математики в условиях интеграции искусственного интеллекта (ИИ)

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Didactic process of teaching higher mathematics in the context of integration of artificial intelligence (AI)

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Abstract:

Currently, the implementation of AI technologies aims to increase the efficiency of the educational process. In higher mathematics, students need a deep understanding of complex abstract concepts and practical applications of mathematical principles.

Our research (grant No. AP23489530, funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan) focuses on integrating artificial intelligence (AI) into the educational process of higher mathematics to develop a more effective didactic system. The report will present methods for overcoming traditional challenges, such as the high complexity of the material, varying levels of student preparation, and the limited ability of instructors to provide individualized support, through the integration of AI in higher mathematics education.

Keywords: Didactic process, teaching higher mathematics, artificial intelligence, integration of artificial intelligence,

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INTRODUCTION

Currently, the implementation of AI technologies aims to increase the efficiency of the educational process. In higher mathematics, students need a deep understanding of complex abstract concepts and the practical application of mathematical principles.

Our research (grant No. AP23489530, funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan) focuses on integrating artificial intelligence (AI) into the educational process of higher mathematics to develop a more effective didactic system.

This report will present methods for overcoming traditional challenges, such as the high complexity of the material, varying levels of student preparation, and the limited ability of instructors to provide individualized support, through the integration of AI in higher mathematics education.

SUMMARY

Mathematics has always held relevance across a wide range of professional fields, and the teaching of higher mathematics in universities is often accompanied by various difficulties that hinder students' comprehension of the material and diminish their overall motivation to learn. These challenges stem from several factors, including the inherent nature of the discipline, the instructional methodologies employed, and the specific characteristics of the educational environment.

An analysis of recent academic literature reveals key challenges in teaching higher mathematics at the university level. As shown in research [1], a significant proportion of students (73.6%) exhibit cognitive resistance to learning due to the abstract nature of

the subject and its complex logical structures. One notable difficulty lies in students’ inability to connect mathematical theory with real-world application, which in turn reduces both engagement and perceived relevance of the subject. Additional obstacles include low motivation levels and a shortage of qualified teachers, further impeding the effectiveness of learning [2].

Nevertheless, there are notable advantages to the instructional process. The use of mathematical modeling and problem-based tasks can significantly enhance students’ conceptual understanding and retention. Paradoxically, the inherent difficulties of higher mathematics can also serve as a catalyst for the development of critical thinking and problem-solving skills across diverse disciplines. This underscores the importance of fostering resilience and adaptability in the learning process [3].

Numerous studies have proposed strategies to overcome these traditional barriers and improve the effectiveness of teaching university-level mathematics. In the study[4], the authors emphasize the value of interactive teaching methods, team work, case-based tasks, and «the flipped classroom» model.

Fu [5] proposes a six-step problem-based learning (PBL) framework aimed at fostering learner independence and innovative thinking. A practice-oriented teaching approach [6] has also demonstrated a positive impact on student engagement and learning outcomes. Furthermore, the automation of routine calculations through task generators [7] allows instructors to allocate more time toward the development of analytical thinking.

Building on both the reviewed literature and extensive teaching experience in higher education, a matrix of methods for addressing challenges in teaching higher mathematics was developed. (Fig. 1)

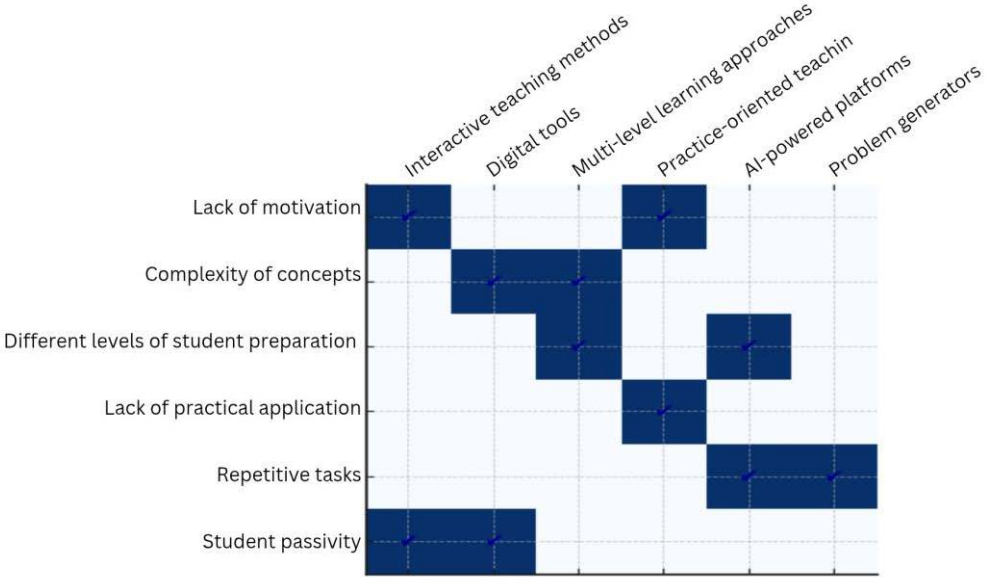

Fig. 1. Matrix of methods for overcoming challenges in teaching higher mathematics

With the widespread integration of AI tools, our research focuses on answering the following questions:

1. How can the complexities of mathematics material be mitigated using AI in the classroom?

2. How can higher mathematics be taught to students with varying levels of preparation using AI?

3. How can the limitations of instructors in providing individualized support be overcome through AI integration?

Artificial Intelligence (AI) tools are widely employed to address traditional teaching challenges. Research [8] shows that AI can enhance understanding of complex concepts through instant feedback and personalized explanations. In the study [9], the potential of AI to increase engagement and reduce distractions is emphasized. The use of eye-tracking data [10] allows AI to identify cognitive overload in real-time and adjust the delivery of the material accordingly.

2. How can higher mathematics be taught to students with varying levels of preparation using AI?

AI enables the adaptation of learning paths to individual educational trajectories. In the article [11], a model based on ant colony algorithms and convolutional neural networks is proposed, demonstrating improved performance for students of varying levels of preparation. AI also plays a significant role in creating adaptive, game-based, and immersive learning formats that promote deeper understanding of the material [12]-[13]. AI-powered platforms track student progress, recommend personalized resources, and adjust learning pace [14].

3. How can the limitations of instructors in providing individualized support be overcome through AI integration?

While AI does not replace the instructor, it enhances their ability to provide individualized student support. Studies [15]-[16] highlight the importance of professional development for teachers in the field of AI. Supporting teachers in AI integration requires training, knowledge exchange, and the creation of a conducive environment [17]. It is noted that AI is effective when ethically and carefully integrated into educational practices, while preserving the critical aspects of human interaction [18].

Currently, didactic processes aimed at developing students' cognitive activities are responsible for forming their knowledge base, reinforcing skills in solving various tasks, and fostering intellectual and creative abilities.

In the paper [19], it is shown that didactic engineering includes both the steps of analyzing, developing, and designing educational products, as well as their application in the educational process to achieve the desired learning outcomes. It is known that didactic engineering is based on applying engineering methodologies to study teaching and learning processes.

Due to the dynamic development of digital technologies, didactics requires careful study and research considering the transformation of educational processes. Therefore, to develop a more effective didactic system within the scope of the scientific research on the integration of Artificial Intelligence (AI) in higher mathematics education (grant № AP23489530), a didactic process for teaching higher mathematics based on AI tools, incorporating didactic engineering principles, has been constructed (Fig. 2).

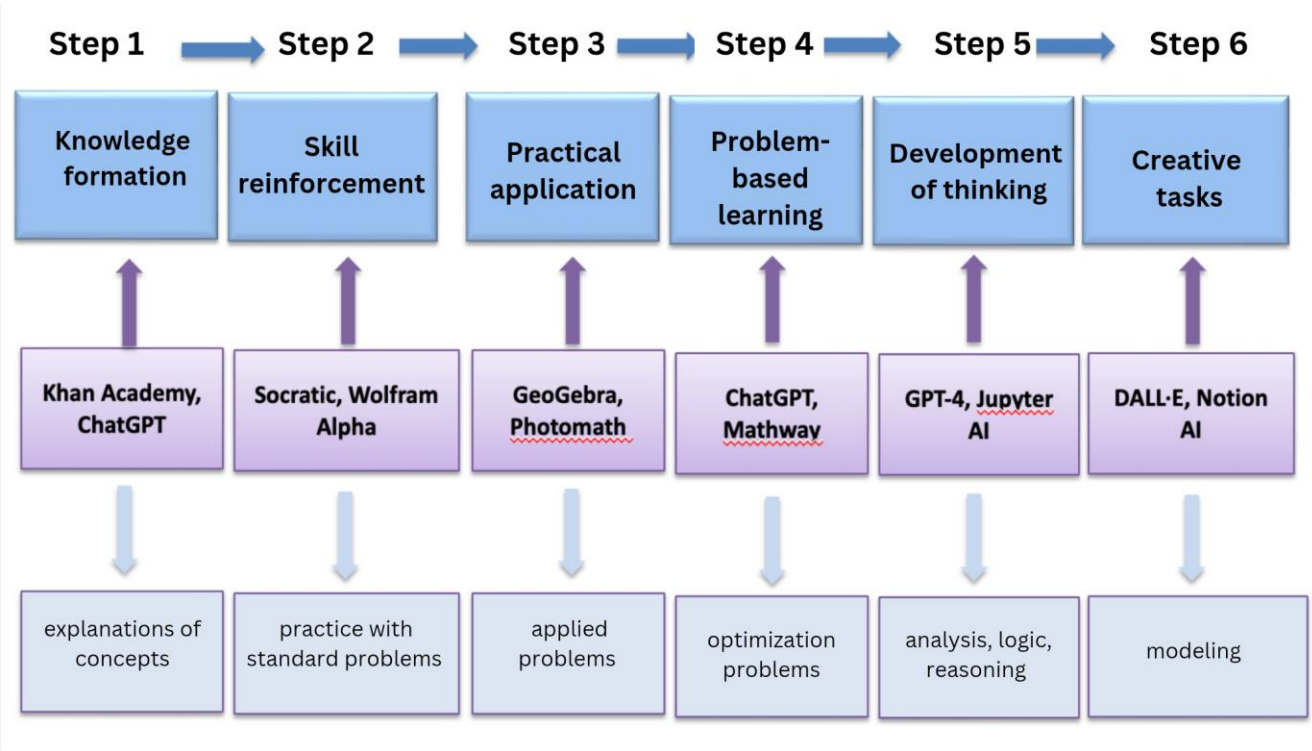

Fig. 2. Didactic process of teaching higher mathematics based on AI tools.

Let us examine the diagram of the didactic process for teaching higher mathematics, using the topic "Derivatives and Their Applications" as an example (Fig. 3).

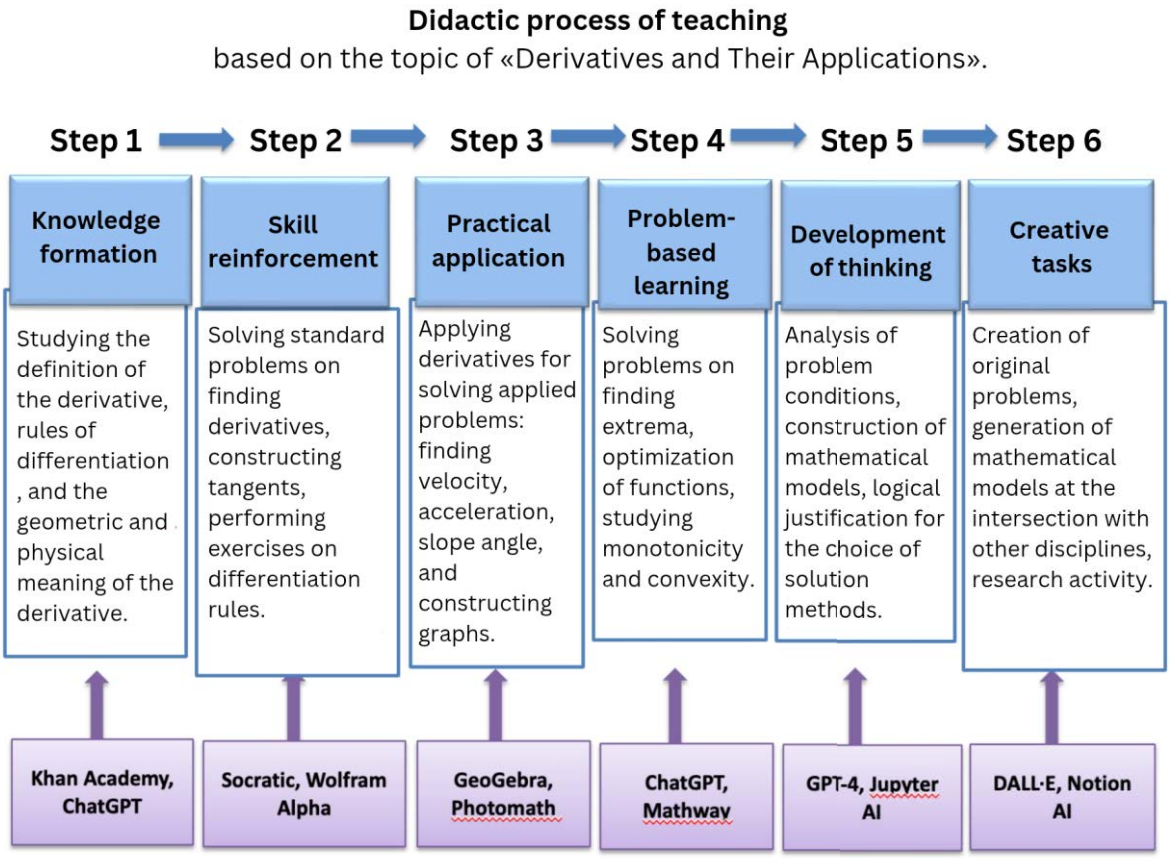

Fig. 3. Didactic process of teaching, using the example of the topic "Derivatives and Their Applications."

The initial stage of the didactic process involves the formation of the student's knowledge base, which is achieved through the assimilation of definitions, formulas, theorems, and methods for calculating derivatives. In the next stage, through solving standard problems and completing practical assignments, the skills and abilities necessary for the correct application of the studied theoretical material are consolidated. In the third stage, during the solution of applied problems, students engage in active cognitive activities. The development of analytical and logical thinking is facilitated by active mental activities, such as analyzing the problem conditions, constructing a mathematical model, and selecting a solution method. Furthermore, at subsequent stages, if students are offered to modify the task, generalize the problem conditions, or create a similar problem with a real-world context, they demonstrate intellectual initiative and a creative approach. Thus, well-organized didactic processes in higher mathematics not only perform educational and developmental functions but also serve a formative function—shaping mathematical culture and research competence.

CONCLUSION

Artificial intelligence (AI) does not replace the instructor but enhances their ability to provide individualized support to students. AI can be viewed as an additional tool that performs routine tasks, provides instant feedback, and improves personalized support by conducting data analysis.

Thus, the didactic process of teaching higher mathematics based on artificial intelligence involves not only the transmission of formulas and reasoning algorithms but also the organization of learning that stimulates thinking, creates conditions for practical application, and develops the intellect and creative thinking of the student.

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