DIDACTIC OPPORTUNITIES AND LIMITATIONS OF INTEGRATING "CHATGPT" AND OTHER ARTIFICIAL INTELLIGENCE TOOLS INTO MATHEMATICS EDUCATION

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Abstract. *This article theoretically and analytically examines the didactic opportunities and limitations of integrating artificial intelligence tools such as "ChatGPT" and "Claude" into the mathematics curriculum in higher education. The methodological foundation of the study is based on the constructivist approach (J. Piaget, L. S. Vygotsky) and cognitive load theory (J. Sweller). The article analyzes the main didactic opportunities of artificial intelligence tools in mathematics education — individualized explanation and feedback, demonstration of various problem-solving methods, differentiation of learning materials, and their application as a tool for Socratic dialogue. At the same time, significant pedagogical limitations of these tools are also considered, including the possibility of mathematical errors, the risk of weakening students' independent thinking skills, issues of academic integrity, and problems related to digital inequality. Based on the results of the analysis, a methodological model aimed at the pedagogically effective use of artificial intelligence tools in teaching mathematics in higher education is proposed. This model includes viewing artificial intelligence as a supportive tool, fostering critical thinking, and employing a strategy of transitioning to process-based assessment.*

Keywords: *artificial intelligence, ChatGPT, Claude, didactic opportunities, constructivism, differentiated instruction, academic integrity*

ДИДАКТИЧЕСКИЕ ВОЗМОЖНОСТИ И ОГРАНИЧЕНИЯ ИНТЕГРАЦИИ "CHATGPT" И ДРУГИХ ИНСТРУМЕНТОВ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В ОБУЧЕНИЕ МАТЕМАТИКЕ

Аннотация. *В данной статье теоретически и аналитически рассматриваются дидактические возможности и ограничения интеграции инструментов искусственного интеллекта, таких как "ChatGPT" и "Claude", в учебную программу по математике в высшем образовании. Методологической основой исследования является конструктивистский подход (Ж. Пиаже, Л. С. Выготский) и теория когнитивной нагрузки (Дж. Суэллер). Статья анализирует основные дидактические возможности инструментов искусственного интеллекта в обучении математике — индивидуализированное объяснение и обратная связь, демонстрация различных методов решения задач, дифференциация учебных материалов, а также их применение в качестве инструмента для сократического диалога. В то же время рассматриваются значительные педагогические ограничения этих инструментов, включая возможность математических ошибок, риск ослабления навыков*

самостоятельного мышления студентов, вопросы академической честности и проблемы, связанные с цифровым неравенством. На основе результатов анализа предлагается методическая модель, направленная на педагогически эффективное использование инструментов искусственного интеллекта в преподавании математики в высшем образовании. Эта модель включает рассмотрение искусственного интеллекта как вспомогательного инструмента, развитие критического мышления и применение стратегии перехода к оценке на основе процесса.

Ключевые слова: *искусственный интеллект, ChatGPT, Claude, дидактические возможности, конструктивизм, дифференцированное обучение, академическая честность*

MATEMATIKA TA'LIMIDA "CHATGPT" VA BOSHQA SUN'IY INTELLEKT VOSITALARINI INTEGRATSIYA QILISHNING DIDAKTIK IMKONIYATLARI VA CHEKLOVLARI

Annotatsiya: *Mazkur maqolada oliy ta'lim tizimida matematika fanini o'qitishda "ChatGPT" va "Claude" kabi sun'iy intellekt vositalarini o'quv jarayoniga integratsiya qilishning didaktik imkoniyatlari va cheklovlari nazariy va tahliliy jihatdan ko'rib chiqiladi. Tadqiqotning metodologik asosini konstruktivistik yondashuv (J. Piaje, L. S. Vygotskiy) hamda kognitiv yuklama nazariyasi (J. Sueller) tashkil etadi. Maqolada sun'iy intellekt vositalarining matematika ta'limidagi asosiy didaktik imkoniyatlari — individuallashtirilgan tushuntirish va qayta aloqa, masalalarni yechishning turli usullarini namoyish etish, o'quv materiallarini differensiallashtirish, shuningdek, ularni sokratik dialog vositasi sifatida qo'llash tahlil qilinadi. Shu bilan birga, ushbu vositalarning muhim pedagogik cheklovlari ham yoritiladi, jumladan, matematik xatolar ehtimoli, talabalarning mustaqil fikrlash ko'nikmalarining susayish xavfi, akademik halollik masalalari hamda raqamli tengsizlik bilan bog'liq muammolar. Tahlil natijalari asosida oliy ta'limda matematika fanini o'qitishda sun'iy intellekt vositalaridan pedagogik jihatdan samarali foydalanishga qaratilgan metodik model taklif etiladi. Ushbu model sun'iy intellektni yordamchi vosita sifatida ko'rish, tanqidiy fikrlashni rivojlantirish hamda jarayonga asoslangan baholash strategiyasini qo'llashni o'z ichiga oladi.*

Kalit so'zlar: *sun'iy intellekt, ChatGPT, Claude, didaktik imkoniyatlar, konstruktivizm, differensial ta'lim, akademik halollik.*

INTRODUCTION

Today, artificial intelligence technologies are rapidly penetrating all spheres of society, including the education system. The ChatGPT tool, presented by OpenAI in November 2022, in turn, sparked widespread discussion among educational institutions, teachers, and researchers around the world. Within a year, this tool, whose number of users exceeded 100 million, became one of the fastest-growing

technological products in human history. Following it, Anthropic's "Claude," Google's "Gemini," and other competing models also began entering the field of education. These tools have moved beyond simply answering basic questions and have acquired the ability to solve complex mathematical problems, provide explanations, conduct assessments, and generate instructional materials.

Mathematics education is a field that requires abstract concepts, strict logical consistency, and problem-solving skills. On the one hand, models such as "ChatGPT" and "Claude" provide students with the opportunity to receive individualized explanations, step-by-step clarification of problems, and immediate feedback—processes that are not always feasible in traditional education due to the limited time available to teachers. On the other hand, the tendency of these tools to produce mathematical errors, the risk of weakening students' independent thinking abilities, and issues of academic integrity are giving rise to serious pedagogical concerns.

In the higher education system of Uzbekistan, the process of digital transformation is being supported at the level of state policy. Within the framework of the "Digital Uzbekistan — 2030" strategy, adopted by the President of the Republic of Uzbekistan on September 19, 2023, the digitalization of the education sector has been included among the priority areas. At the same time, the methodological foundations for integrating artificial intelligence tools, particularly into mathematics education, have not yet been sufficiently developed in local pedagogical research. This determines the relevance of the present article.

The aim of this article is to theoretically and analytically examine the didactic opportunities and limitations of integrating artificial intelligence tools such as "ChatGPT" and "Claude" into the teaching of mathematics courses in higher education, as well as to develop methodological recommendations aimed at their effective use.

The article analyzes international research and theoretical approaches in the field of implementing artificial intelligence tools in education. The didactic opportunities of "ChatGPT" and "Claude" in mathematics education are identified. The pedagogical limitations and risks associated with the use of these tools are examined. Practical methodological recommendations for teachers are proposed.

METHODOLOGY

The application of artificial intelligence in education — "Artificial Intelligence in Education" (AIEd) — began to take shape as an independent scientific field in the 1980s and has today become a rapidly developing area of research. However, the emergence of large language models (LLMs) such as ChatGPT has added an entirely new dimension to this field. The first LLM-based educational studies increased sharply from 2023 onward and were widely discussed in prestigious journals such as "Nature," "Science," and "Educational Researcher."

Researchers Kasneci et al. (2023), in their article entitled "ChatGPT for Good?", systematically analyzed the opportunities and risks of LLM tools in education and emphasized that these tools may fundamentally transform the educational paradigm. In particular, they noted that personalization — that is, education adapted to the individual needs of each student — acquires a new quality through LLMs. Binte et al. (2023), in a specialized study on mathematics education, tested the accuracy of ChatGPT in solving algebra and calculus problems and found that the tool is satisfactory for intermediate-level tasks but remains limited in handling complex problems.

In the 2023 document "Guidance for Generative AI in Education and Research," UNESCO emphasized the need for caution in introducing generative artificial intelligence tools into education and identified several key principles — human oversight, transparency, and academic integrity — as primary criteria.

Among studies specific to mathematics education, the work of Wardat et al. (2023), devoted to integrating ChatGPT into mathematics instruction in higher education, is of particular significance. This research demonstrated that using ChatGPT as an explanatory tool helped improve students' level of understanding; however, excessive reliance on the tool may lead to the weakening of independent thinking skills.

Several pedagogical theories serve as important methodological foundations for theoretically substantiating the integration of artificial intelligence tools into mathematics education.

From the perspective of the constructivist approach (J. Piaget, L. S. Vygotsky), the proper use of ChatGPT or Claude can transform a student from a passive recipient of knowledge into an active constructor of knowledge. For this purpose, instead of requesting ready-made answers, the tool should be used as a source of guiding questions. For example, when a student asks, "Through which steps can I solve this problem?", ChatGPT can compel the student to employ their own reasoning. From the standpoint of L. S. Vygotsky's concept of the "zone of proximal development," an artificial intelligence tool can virtually substitute the teacher's assistance within the range of tasks that a student cannot accomplish independently but can complete with support.

This study is theoretical-analytical in nature. The following methods were employed in the research:

1. Analysis of international scientific literature and pedagogical studies;
2. Examination of the tools ChatGPT (GPT-4 and GPT-4o versions) and Claude (Claude 3 and Claude 3.5 versions);
3. Analysis of local and international regulatory documents concerning the methodology of teaching mathematics in higher education.

The methodological foundation of the study is based on the constructivist approach (J. Piaget, L. S. Vygotsky) and cognitive load theory (J. Sweller).

For the purposes of analysis, sample questions and problems from the following areas of mathematics were presented to ChatGPT and Claude:

1. Linear algebra (matrix operations, determinants);
2. Mathematical analysis (limit, derivative, integral);
3. Probability theory;
4. Mathematical logic.

Practical Part. The greatest limitation of traditional education is that a teacher cannot provide individual attention to dozens of students simultaneously. ChatGPT and Claude offer a practical solution to this problem. Each student can ask questions at a convenient time, according to their level of understanding, and receive immediate clarification. For example, a student struggling to master methods of integration may ask ChatGPT, "Explain the method of integration by parts to me step

by step, using a simple example," and the tool will provide a clear and coherent explanation tailored to the student's request. The pedagogical value of this opportunity lies in the fact that students do not hesitate to ask artificial intelligence questions they might be too shy to ask a teacher or unable to raise due to time constraints. This removes psychological barriers and democratizes the learning process.

Artificial intelligence tools are capable of explaining a single problem through several different solution methods. For instance, they can demonstrate how to find the roots of a quadratic equation using the algebraic method, the graphical method, and the formula — presenting all three approaches. This develops the student's ability to perceive the broader mathematical landscape and helps them understand which method is more appropriate in a given situation.

Comparative analysis shows that Claude often adheres more consistently to step-by-step logical progression in mathematical explanations than ChatGPT and explains the reasoning behind solutions more explicitly. ChatGPT, on the other hand, may occasionally omit steps or shorten intermediate explanations in more complex problems.

With the assistance of ChatGPT or Claude, a teacher can quickly prepare sets of problems at various levels of difficulty, as well as test questions and assessment tasks. This saves the teacher's time and allows for the creation of diverse materials covering different aspects of a topic. For example, it is possible to prepare basic, intermediate, and advanced-level problem sets on the topic of "The Derivative of a Function" within a few minutes. Furthermore, artificial intelligence tools can simplify or complicate materials according to the student's level, which corresponds to the fundamental principle of differentiated instruction.

ChatGPT and Claude can analyze a student's solution, identify where an error has occurred, and suggest the correct direction. For example, if a student incorrectly applies the chain rule while calculating a derivative, artificial intelligence can detect the mistake, explain why it occurred, and demonstrate the correct steps. This feedback mechanism accelerates the student's process of learning from mistakes.

The highest didactic value of artificial intelligence tools is manifested when they are used for Socratic dialogue. For this purpose, the teacher must instruct students not to request ready-made answers from the tool, but to use it as a source of guiding questions. For example, a student states: "I cannot solve this problem." The correct approach is: "Ask ChatGPT what I should determine first in this problem." The incorrect approach is: "Ask ChatGPT to give the answer to this problem." This distinction defines the boundary between fostering critical thinking and undermining it.

ChatGPT and Claude can provide extensive information about the historical origins of mathematical concepts, their practical applications, and their connections with other disciplines. For example, in response to the question, "Why was the integral invented, and where is it applied in real life?", artificial intelligence can offer an accurate and engaging explanation from an educational perspective.

Limitations and Risks of Using Artificial Intelligence Tools in Mathematics Education.

The most serious drawback of artificial intelligence tools, including ChatGPT and Claude, is their potential to make mathematical errors. This phenomenon is referred to in the scientific literature as "hallucination." The model may appear reliable but provide incorrect answers. This is particularly dangerous in mathematics, as a student may accept a wrong answer as correct and reinforce incorrect concepts.

Research shows that ChatGPT and Claude are relatively accurate in algebraic manipulations and standard calculations, but the likelihood of errors increases significantly for poorly formulated problems, ambiguous conditions, or complex multi-step proofs.

Excessive reliance on artificial intelligence tools can weaken a student's ability to think independently in mathematics. If a student immediately turns to ChatGPT for every problem, their skills in analyzing problems independently, developing strategies, and seeking solutions with perseverance will not develop. From a psychological perspective, the difficulty and struggle inherent in independently solving a mathematical problem constitute an essential part of learning. Artificial

intelligence can shorten this process, which may negatively affect cognitive development.

The availability of ChatGPT and Claude has sharply intensified issues of academic integrity. Students may use artificial intelligence to complete homework, independent assignments, and even examinations, creating a real risk. This problem can be addressed not only through technical limitations but also by revising assessment methodologies within the education system.

In some cases, ChatGPT and Claude may explain mathematical concepts ambiguously, incompletely, or pedagogically inaccurately. This is especially problematic for beginner-level students, as it can lead to the formation of misconceptions. For instance, oversimplifying the definition of a limit or omitting crucial conditions when connecting integration to area calculations can create problems that are difficult to correct later.

In the context of Uzbekistan, a particularly important limitation is the problem of digital inequality. Fully capable versions of ChatGPT (GPT-4 and higher) require a paid subscription, and extended versions of Claude are also limited. Not all students have equal access to these tools, which suggests that artificial intelligence should be considered as an additional, optional resource rather than a primary instructional tool.

Widespread use of artificial intelligence tools may, in some cases, create the false impression that students can learn without a teacher. However, the teacher's role — providing motivation, guidance, a supportive environment, and attending to the student's individual and psychological needs — can never be fully replaced by artificial intelligence. Preserving the human dimension of pedagogical interaction is one of the most important tasks for teachers during this technological transformation.

Based on the analysis of the opportunities and limitations described above, the following methodological model is proposed for the effective use of ChatGPT and Claude in teaching mathematics courses in higher education:

1. *Tool — not teacher, but assistant.* Artificial intelligence tools should never be regarded as the primary source of instruction. They should be used to enrich the

teacher's explanations, support independent student learning, and provide additional practice opportunities.

2. *Developing critical thinking.* Students must be taught to critically evaluate all information obtained from artificial intelligence. In class, the teacher can deliberately present exercises using incorrect answers from ChatGPT or Claude — students must identify and correct the mistakes. This develops both mathematical skills and critical thinking.

3. *Process-based assessment.* In the presence of artificial intelligence, assessments based solely on correct answers are losing relevance. Greater attention should be given to the thinking process — how students approached a problem, what mistakes they made, and how they corrected them.

4. *Socratic prompt strategy.* Teachers should instruct students in the skill of asking the right questions. Instead of "Give me the answer to this problem," students should ask, "What strategies can I use to solve this problem?" or "I applied the following method — is it correct, and why?" Such questions activate critical thinking.

5. *Differentiated integration.* Rather than immediately introducing artificial intelligence tools throughout the course, it is recommended to integrate them gradually, step by step.

CONCLUSION

This article theoretically and analytically examined the didactic opportunities and limitations of integrating artificial intelligence tools such as ChatGPT and Claude into university-level mathematics courses.

The analysis conducted allowed for the following key conclusions. Artificial intelligence tools can serve as an effective didactic means in mathematics education by providing individualized explanations and immediate feedback, demonstrating multiple methods of problem-solving, differentiating instructional materials, and facilitating Socratic dialogue. These opportunities are particularly practically significant in higher education settings, where providing individual attention to large groups is challenging.

At the same time, these tools have serious pedagogical limitations. The likelihood of mathematical errors, the risk of weakening independent thinking skills,

issues of academic integrity, and concerns regarding digital inequality must not be overlooked.

The proposed methodological model outlines the main directions for pedagogically appropriate use of artificial intelligence tools: viewing the tool as an assistant, fostering critical thinking, implementing process-based assessment, and ensuring correct pedagogical application of AI tools.

In the future, the effectiveness of these methodological approaches should be empirically tested through experimental research, practical guides adapted to the conditions of higher education institutions in Uzbekistan should be developed, and systems for preparing teachers to work with artificial intelligence tools should be established as promising tasks.

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