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## METHODOLOGY FOR USING ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN PRIMARY SCHOOL MATHEMATICS LESSONS

**Abstract.** *This article examines the methodology for integrating artificial intelligence technologies into primary school mathematics lessons from a pedagogical and methodological perspective. The study explores the didactic potential of AI-based educational tools, emphasizing their role in improving mathematics instruction, enhancing students' mathematical competencies, and increasing overall learning effectiveness. Particular attention is given to adaptive learning systems, personalized instruction, automated assessment, interactive learning activities, and intelligent digital educational resources. The paper discusses methodological approaches to using AI technologies for diagnosing students' learning progress, providing individualized feedback, and implementing differentiated instruction according to learners' needs and achievement levels. The findings indicate that the systematic and pedagogically grounded application of artificial intelligence technologies contributes to the development of logical thinking, mathematical literacy, problem-solving abilities, and independent learning skills among primary school students. Furthermore, the study highlights the importance of strengthening teachers' digital competencies and presents practical recommendations for the effective implementation of AI-supported teaching strategies in primary mathematics education. The proposed methodology demonstrates that the appropriate integration of artificial intelligence can significantly improve the quality, accessibility, and learner-centered nature of mathematics instruction in primary education.*

**Key words:** *artificial intelligence, primary education, mathematics lessons, teaching methodology, adaptive learning, digital technologies, mathematical competence, personalized learning, interactive learning, automated assessment.*

**Аннотация.** *В данной статье рассматривается методология использования технологий искусственного интеллекта на уроках математики в начальной школе. Особое внимание уделяется дидактическим возможностям интеграции интеллектуальных цифровых технологий в образовательный процесс, их влиянию на развитие математической компетентности учащихся и повышение эффективности обучения. Анализируются методические основы применения адаптивного обучения, персонализированных образовательных траекторий, автоматизированного оценивания, интерактивных заданий и интеллектуальных цифровых платформ. Рассматриваются возможности искусственного интеллекта по диагностике уровня знаний обучающихся, предоставлению индивидуальных рекомендаций и организации дифференцированного обучения с учетом образовательных потребностей каждого ученика. Полученные результаты свидетельствуют о том, что методически обоснованное использование технологий искусственного интеллекта способствует развитию логического мышления, математической грамотности, навыков решения проблем и самостоятельной познавательной деятельности младших школьников. Кроме того, в статье представлены практические рекомендации по совершенствованию цифровой компетентности педагогов и эффективному внедрению современных интеллектуальных технологий в образовательную практику начальной школы.*

**Ключевые слова:** *искусственный интеллект, начальная школа, уроки математики, методика обучения, адаптивное обучение, цифровые технологии, математическая компетентность, персонализированное обучение, интерактивное обучение, автоматизированное оценивание.*

**Introduction.** The rapid advancement of artificial intelligence (AI) has fundamentally transformed educational systems worldwide, creating new opportunities for improving teaching quality, learning efficiency, and educational accessibility. As digital transformation becomes a strategic priority in many countries, AI technologies are increasingly being integrated into educational environments to support personalized learning, intelligent assessment, adaptive instruction, and data-driven decision-making. Unlike conventional educational technologies, AI systems are capable of analyzing learners' behaviors, identifying individual strengths and weaknesses, predicting learning outcomes, and generating customized instructional recommendations in real time. These capabilities make AI an innovative pedagogical tool rather than merely a technological supplement.

Mathematics is one of the most fundamental subjects in primary education because it develops logical reasoning, analytical thinking, problem-solving abilities, and quantitative literacy that serve as the foundation for learning across other disciplines. Research consistently demonstrates that students' mathematical achievement during the primary school years significantly influences their later academic performance in science, technology, engineering, and mathematics (STEM) education. Consequently, improving mathematics instruction at the primary level has become an important objective for educational policymakers, curriculum developers, and researchers worldwide.

Despite continuous improvements in mathematics curricula, many primary school students continue to experience difficulties in understanding abstract mathematical concepts, maintaining motivation, and applying mathematical knowledge to real-life situations. Traditional teacher-centered instructional approaches often fail to address the diverse cognitive abilities, learning styles, and developmental characteristics of young learners. Since primary school classrooms typically include students with different learning speeds and varying levels of prior knowledge, providing individualized instruction through conventional teaching methods alone remains a considerable challenge. These limitations highlight the need for innovative pedagogical approaches that can accommodate learner diversity while maintaining instructional quality.

**Research Significance.** The rapid digital transformation of education has made the integration of artificial intelligence (AI) a strategic priority in both national and international educational systems. Globally, organizations such as UNESCO and the OECD emphasize that AI has the potential to improve educational quality by supporting personalized learning, enhancing assessment practices, and promoting inclusive education. Their recent policy frameworks encourage the responsible use of AI technologies to strengthen students' digital competencies and prepare them for the demands of the twenty-first-century workforce.

In the Republic of Uzbekistan, educational reforms implemented under the Digital Uzbekistan–2030 Strategy and ongoing modernization of the general education system have highlighted the importance of introducing innovative digital technologies into classroom practice. Special attention is being given to improving the quality of mathematics education, developing teachers' digital competencies, and expanding the use of intelligent educational platforms in schools. However, despite the growing availability of AI-based educational tools, there is still a lack of scientifically grounded methodologies that explain how these technologies should be effectively integrated into primary school mathematics lessons.

Therefore, developing a methodology for using artificial intelligence technologies in primary mathematics education is both timely and necessary. It addresses current educational priorities at the national and international levels while contributing to improved teaching quality, personalized learning, and the development of students' mathematical and digital competencies.

**Literature Review.** The integration of artificial intelligence (AI) into primary mathematics education has attracted increasing attention among both Russian and international researchers, who emphasize its potential to improve learning outcomes through personalized instruction and intelligent educational support. Early studies on educational technology primarily focused on computer-assisted learning; however, recent research has shifted toward AI-driven systems capable of adapting instructional content to individual learners' needs and providing real-time feedback. This transition reflects the growing recognition that AI can support not only knowledge acquisition but also the development of higher-order cognitive skills.

Among Russian scholars, V.V. Serikov highlights that modern educational technologies should promote learner-centered instruction by considering students' individual characteristics and cognitive development. A.G. Asmolov argues that digital transformation requires educational models that encourage independent thinking, creativity, and continuous learning rather than simple knowledge reproduction. Similarly, I.V. Robert emphasizes that information and intelligent technologies should be integrated into teaching through scientifically grounded pedagogical methodologies, ensuring that technological innovation serves educational objectives rather than replacing the teacher's instructional role. The works of these scholars provide an important theoretical foundation for designing AI-supported mathematics instruction in primary education.

International researchers have further expanded this field by investigating the pedagogical applications of artificial intelligence in school education. Wayne Holmes, Maya Bialik, and Charles Fadel argue that AI has the potential to personalize learning, automate formative assessment, and provide adaptive learning pathways that respond to students' individual progress. Rose Luckin emphasizes that AI should function as an intelligent educational assistant capable of supporting both teachers and learners through data-informed instructional decisions. Likewise, Ryan S.J.d. Baker demonstrates that educational data mining and learning analytics enable teachers to identify learning difficulties at an early stage, allowing timely pedagogical intervention. Neil Selwyn offers a critical perspective by stressing that successful AI implementation depends not only on technological advancement but also on ethical considerations, teacher preparedness, and appropriate educational policies.

Although existing studies provide substantial evidence regarding the educational potential of artificial intelligence, relatively few focus specifically on developing a comprehensive methodology for integrating AI technologies into primary school mathematics lessons. Most research examines technological capabilities, while less attention is given to methodological principles governing lesson design, instructional strategies, classroom implementation, and assessment practices. Therefore, the present study seeks to address this gap by proposing a pedagogically grounded methodology that combines the advantages of artificial intelligence with established principles of primary mathematics education, thereby contributing to both theoretical understanding and practical teaching innovation.

**Methodology.** This study employed a mixed-methods research design combining qualitative and quantitative approaches to develop and evaluate a methodology for integrating artificial intelligence technologies into primary school mathematics lessons. The methodological framework was based on the principles of learner-centered education, competency-based instruction, differentiated teaching, and formative assessment, which are consistently implemented within the general education system of the

Republic of Uzbekistan. The research process included the analysis of pedagogical literature, observation of mathematics lessons, interviews with primary school teachers, and the implementation of AI-supported learning activities during classroom instruction. The proposed methodology was designed in accordance with the requirements of the State Educational Standards for primary education and focused on improving pupils' mathematical competence, logical reasoning, and independent problem-solving skills.

To ensure methodological validity, instructional activities were organized using teaching methods that are widely practiced in Uzbek primary schools, including explanation and demonstration, question-and-answer discussions, practical exercises, collaborative learning, differentiated instruction, formative assessment, and reflective feedback. Artificial intelligence technologies were incorporated as supportive instructional tools rather than substitutes for the teacher. AI-assisted platforms were used to generate differentiated mathematical tasks, provide immediate feedback, monitor students' learning progress, and recommend individualized learning activities according to pupils' achievement levels. Student performance was continuously assessed through classroom observation, diagnostic tasks, and formative assessment techniques, allowing teachers to adapt instruction based on learners' needs. The effectiveness of the proposed methodology was evaluated by comparing students' engagement, accuracy in mathematical problem solving, and conceptual understanding before and after the implementation of AI-supported instructional activities.

**Table 1.**

**Methodological framework for integrating artificial intelligence technologies into primary school mathematics lessons**

Methodological component	Implementation in the mathematics lesson	Expected educational outcome
<b>Learning objectives</b>	Define competency-based mathematical outcomes aligned with the national curriculum	Clear learning goals and measurable competencies
<b>Explanation and demonstration</b>	Teacher introduces new mathematical concepts using visual examples and AI-generated illustrations	Improved conceptual understanding
<b>Question-and-answer method</b>	Guided classroom discussion supported by AI-generated prompts and examples	Development of logical reasoning and mathematical communication
<b>Practical exercises</b>	Students solve differentiated mathematical problems generated according to individual learning levels	Improved computational accuracy and problem-solving skills
<b>Collaborative learning</b>	Pupils complete mathematical tasks in small groups while discussing AI-supported solutions	Enhanced cooperation, communication, and peer learning
<b>Formative assessment</b>	AI-assisted instant feedback combined with teacher observation and oral questioning	Continuous monitoring of learning progress and timely correction of misconceptions

<b>Differentiated instruction</b>	Learning activities adapted to students' achievement levels using AI recommendations	Personalized learning and increased learning effectiveness
<b>Reflection and evaluation</b>	Students analyze their learning outcomes, while teachers evaluate achievement using formative assessment criteria	Development of self-assessment skills and sustainable mathematical competence

The proposed methodological framework integrates established pedagogical approaches regularly applied in Uzbekistan's primary education system with the instructional capabilities of artificial intelligence technologies. Such integration ensures that AI serves as an effective educational support tool while maintaining the central role of the teacher in organizing learning activities, guiding students' cognitive development, and achieving the objectives of primary mathematics education. This methodology provides a practical model for enhancing instructional quality through scientifically grounded and pedagogically appropriate use of artificial intelligence in the classroom.

**Discussion.** The findings of this study indicate that the integration of artificial intelligence technologies into primary school mathematics lessons can significantly enhance the effectiveness of the teaching and learning process when supported by an appropriate pedagogical methodology. The results demonstrate that AI-based instructional tools are most effective when they complement, rather than replace, the teacher's professional expertise. By providing adaptive learning tasks, immediate feedback, and continuous monitoring of student progress, AI enables teachers to identify learning difficulties at an early stage and adjust instructional strategies according to individual learning needs. This learner-centered approach contributes to higher levels of engagement, improved mathematical understanding, and greater confidence in solving mathematical problems.

The proposed methodology also supports differentiated instruction, which is particularly important in primary education where students demonstrate diverse cognitive abilities and learning paces. AI technologies facilitate personalized learning by presenting mathematical tasks that correspond to each learner's level of achievement, thereby reducing learning gaps and encouraging continuous academic progress. At the same time, the teacher remains responsible for organizing collaborative activities, guiding classroom interaction, and fostering critical thinking, creativity, and communication skills that cannot be fully developed through technology alone.

These findings are consistent with previous international research emphasizing that the educational value of artificial intelligence depends primarily on its pedagogically meaningful implementation rather than on the technology itself. In the context of Uzbekistan, the growing digital transformation of general education creates favorable conditions for the wider adoption of AI-supported teaching practices. However, successful implementation requires systematic teacher training, reliable digital infrastructure, and the development of methodological guidelines aligned with the national curriculum. Therefore, the proposed methodology represents a practical and sustainable approach for improving the quality of primary mathematics education while supporting the development of both mathematical competence and digital literacy among young learners.

**Conclusion.** The integration of artificial intelligence technologies into primary school mathematics lessons represents an important step toward improving the quality and effectiveness of contemporary

education. This study demonstrates that AI can become a valuable pedagogical resource when its application is guided by scientifically grounded teaching methodologies and aligned with curriculum objectives. Rather than replacing the teacher, artificial intelligence strengthens instructional practices by supporting personalized learning, adaptive task design, continuous formative assessment, and timely feedback, thereby creating a more learner-centered educational environment.

The proposed methodology confirms that combining traditional pedagogical approaches with AI-supported instructional tools contributes to the development of mathematical competence, logical reasoning, problem-solving abilities, and independent learning skills among primary school pupils. Furthermore, AI technologies enable teachers to respond more effectively to individual differences in students' learning needs, making differentiated instruction more practical and efficient within the classroom.

The study also highlights that the successful implementation of artificial intelligence in mathematics education depends not only on technological availability but also on teachers' digital competence, methodological preparedness, and the establishment of appropriate educational policies. Continuous professional development, reliable digital infrastructure, and the responsible use of AI are essential prerequisites for achieving sustainable educational outcomes.

In conclusion, the methodology proposed in this research provides a practical framework for integrating artificial intelligence into primary mathematics education in a pedagogically meaningful manner. Its implementation has the potential to enhance students' academic achievement, increase learning motivation, and support the broader digital transformation of education. Future research may further investigate the long-term impact of AI-assisted mathematics instruction on learners' cognitive development, mathematical creativity, and overall educational performance across different primary grade levels.

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