METHODOLOGICAL EFFECTIVENESS OF USING AI ELEMENTS IN ROBOTICS LESSONS

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ABSTRACT

This article examines the methodological effectiveness of using elements of artificial intelligence (AI) in robotics lessons. The integration of AI technologies into robotics education creates opportunities for developing students' algorithmic thinking, computational thinking, problem-solving, creativity, engineering skills, and digital competencies. The study focuses on the methodological approaches and pedagogical conditions necessary for the effective implementation of AI elements in the educational process. In particular, the use of intelligent control systems, machine learning algorithms, computer vision, voice recognition, and autonomous robotic platforms in robotics lessons is analyzed. The article emphasizes the importance of project-based learning, problem-based learning, inquiry-based learning, and STEM-oriented approaches in organizing AI-integrated robotics education. The findings demonstrate that the systematic use of AI elements increases students' interest in robotics, promotes active participation in the learning process, and contributes to the development of practical and analytical skills. Furthermore, the integration of AI into robotics lessons enhances students' ability to design, program, test, and improve intelligent robotic systems. The article concludes that the methodically sound integration of artificial intelligence into robotics education is an effective means of improving the quality of technology education and preparing students for the demands of the modern digital and technological environment.

Introduction.The rapid development of digital technologies, artificial intelligence, robotics, and automation is significantly transforming the requirements for modern education. In the twenty-first century, the educational process is no longer limited to the transmission of theoretical knowledge. Modern education is increasingly focused on developing students' ability to think critically, solve complex problems, work with digital technologies, design innovative solutions, and apply theoretical knowledge in practical situations. In this context,

robotics education is becoming one of the important areas for developing students' technological and engineering competencies[1].

Robotics is an interdisciplinary field that combines elements of physics, mathematics, computer science, engineering, programming, electronics, and technology. The organization of robotics lessons allows students to develop not only technical knowledge but also logical, algorithmic, creative, analytical, and problem-solving skills. However, the rapid development of modern technologies requires the content and methodology of robotics education to be continuously improved. In particular, the integration of artificial intelligence elements into robotics lessons creates new opportunities for increasing the effectiveness of the educational process[2].

Artificial intelligence is currently one of the most rapidly developing areas of modern science and technology. AI technologies are increasingly being used in various fields, including education, industry, medicine, transportation, economics, and engineering. The use of artificial intelligence in robotics enables robots to perform tasks based on data analysis, environmental recognition, decision-making, machine learning, computer vision, voice recognition, and autonomous control. Therefore, the inclusion of AI elements in the educational process can significantly expand students' understanding of modern intelligent technologies and their practical applications[3].

The integration of artificial intelligence into robotics lessons is important not only from a technological perspective but also from a methodological point of view. Students who work with AI-based robotic systems are involved in a learning process that requires them to identify problems, formulate hypotheses, develop algorithms, program robotic devices, analyze data, test results, and improve their solutions. Such activities contribute to the formation of higher-order thinking skills and develop students' ability to independently search for solutions to complex problems.

The methodological effectiveness of using AI elements in robotics lessons depends on a number of pedagogical conditions. These include the appropriate selection of educational content, the age and cognitive characteristics of students, the level of their digital and programming competencies, the availability of technological equipment, the teacher's methodological competence, and the use of appropriate teaching methods. In this regard, the application of project-based learning, problem-based learning, inquiry-based learning, STEM-oriented education, and collaborative learning can contribute to the effective integration of AI technologies into robotics education[4].

The use of AI elements also changes the role of the teacher in the educational process. The teacher is no longer limited to transmitting knowledge but acts as a facilitator, consultant, organizer, and mentor. Students, in turn, become active participants in the learning process. They independently design robotic systems, develop algorithms, analyze the results of experiments, identify errors, and improve their projects. This process promotes the development of independence, creativity, responsibility, communication, and engineering thinking.In addition, AI-integrated robotics education contributes to the development of students' digital literacy and technological culture. Students become familiar with the basic principles of machine learning, data processing, intelligent control systems, sensor technologies, computer vision, and autonomous robotic systems. Such knowledge and skills

are particularly important for preparing students for future professional activities in the context of the Fourth Industrial Revolution and the growing demand for specialists in digital technologies[5].

The relevance of this study is determined by the need to develop effective methodological approaches for integrating artificial intelligence elements into robotics lessons. Although robotics education has been increasingly introduced into modern schools, the methodological potential of AI-based robotics is not yet fully utilized. Therefore, the development of scientifically grounded and practically oriented approaches to the use of AI elements in robotics lessons is an important task of modern technology education.

The purpose of this study is to analyze the methodological effectiveness of using artificial intelligence elements in robotics lessons and to identify pedagogical approaches that contribute to the development of students' technological, engineering, computational, creative, and problem-solving skills.

To achieve this purpose, the following objectives were identified:

- to analyze the theoretical and methodological foundations of using artificial intelligence in robotics education;
- to identify the pedagogical potential of AI-integrated robotics lessons;
- to examine the role of project-based, problem-based, and STEM-oriented learning in the development of students' technological competencies;
- to determine the methodological conditions for the effective use of AI elements in robotics lessons;
- to analyze the impact of AI-based robotics activities on students' computational thinking, creativity, problem-solving, and engineering skills.

The scientific significance of the study lies in the methodological analysis of the integration of artificial intelligence elements into robotics education and the identification of pedagogical conditions that contribute to the development of students' modern technological competencies. The practical significance of the study is associated with the possibility of using the proposed methodological approaches in robotics lessons, technology education classes, specialized schools, extracurricular educational activities, and STEM-oriented educational programs[6].

LITERATURE REVIEW.The theoretical foundations of robotics education are closely related to the development of constructivist, constructionist, STEM, project-based, and problem-based approaches to learning. Modern educational research emphasizes that students learn more effectively when they actively participate in the process of constructing knowledge through practical activities, experimentation, collaboration, and problem-solving. Robotics provides a particularly favorable environment for implementing such approaches because students can immediately test theoretical concepts through the design and programming of real or virtual robotic systems.Research in the field of STEM education also demonstrates the importance of integrating science, technology, engineering, and mathematics into a unified educational process. Robotics is considered one of the most effective tools for implementing interdisciplinary STEM education. During robotics activities, students apply knowledge of physics to understand movement and forces, mathematics to calculate parameters, computer science to develop algorithms, and engineering principles to

design and improve robotic systems. The integration of AI elements further expands the interdisciplinary potential of robotics education by introducing concepts related to data analysis, machine learning, intelligent decision-making, and autonomous control[7].

A number of researchers have emphasized the importance of robotics in the development of computational thinking. Computational thinking includes the ability to decompose complex problems, identify patterns, abstract essential information, develop algorithms, and evaluate solutions. Programming robots requires students to translate real-world problems into logical sequences of commands. When AI elements are introduced, students are also required to analyze data and understand how intelligent systems make decisions. Therefore, AI-integrated robotics education can contribute to the development of more advanced forms of computational and algorithmic thinking.

The literature on artificial intelligence in education indicates that AI technologies can provide new opportunities for personalized learning, intelligent assessment, adaptive learning environments, and the development of digital competencies. However, the educational use of AI requires careful methodological planning. Researchers emphasize that students should not merely use ready-made AI tools but should understand the basic principles of how intelligent systems function. In robotics lessons, this can be achieved through practical activities involving sensors, data collection, classification, machine learning models, computer vision, and autonomous decision-making.

Studies on the use of educational robotics platforms such as Arduino-based systems, LEGO-based robotics kits, microcontrollers, and virtual simulation environments demonstrate that practical technological tools can significantly increase students' motivation and engagement. These platforms allow students to gradually move from simple programming tasks to more complex projects involving sensors, automation, intelligent control, and AI technologies.

At the same time, the analysis of existing literature reveals several methodological challenges. First, not all educational institutions have sufficient technological equipment for organizing AI-based robotics activities. Second, teachers may require additional professional development in artificial intelligence, programming, machine learning, and robotics. Third, the integration of AI into lessons requires carefully developed educational materials and age-appropriate methodological approaches. Fourth, the assessment of students' learning outcomes in AI-integrated robotics education requires the use of both traditional and competency-based assessment criteria[8].

MAIN PART

The integration of artificial intelligence into robotics lessons creates new opportunities for improving the quality and effectiveness of technology education. Traditional robotics education is mainly focused on the construction and programming of robotic devices. However, the use of AI elements allows students to move from simple programmed actions to the development of intelligent systems capable of analyzing information, recognizing objects, learning from data, and making decisions.The methodological potential of AI in robotics education can be observed in several important areas. First, artificial intelligence enables the creation of problem-oriented learning environments. Students can work on real-life problems and develop robotic solutions using intelligent technologies. For example, they can design a

robot capable of recognizing objects, avoiding obstacles, identifying colors, following a specific route, or responding to voice commands[9].

Second, AI technologies contribute to the development of computational thinking. When students create an intelligent robotic system, they must analyze a problem, divide it into smaller components, collect and process data, develop an algorithm, test the system, and improve its performance. This process develops logical reasoning and algorithmic thinking.

Third, the use of AI promotes the development of engineering competencies. Students participate in the complete design cycle: identifying a problem, designing a solution, constructing a prototype, programming the system, testing its operation, and making improvements. This process is closely connected with the engineering design process.

The methodological potential of AI-integrated robotics lessons can be represented as follows:

AI Element	Educational Activity	Developed Competencies
Machine learning	Training a robot to classify objects or recognize patterns	Analytical and computational thinking
Computer vision	Recognizing objects, colors, or images	Observation, digital literacy, problem-solving
Voice recognition	Developing voice-controlled robotic systems	Programming and communication skills
Intelligent sensors	Analyzing environmental data	Research and analytical skills
Autonomous control	Making independent robotic decisions	Engineering and critical thinking
Data analysis	Processing and interpreting sensor data	Mathematical and digital competencies

The table shows that each AI element can be associated with specific educational activities and learning outcomes. Therefore, the use of artificial intelligence in robotics lessons should be methodically planned according to the educational objectives and students' level of preparation.

Project-based learning is one of the most effective approaches for integrating AI into robotics education. This method enables students to acquire knowledge through practical activities and the development of a specific technological product.

The organization of an AI-based robotics project can be implemented through the following stages:

Problem identification. Students identify a practical or technological problem.

Research and information gathering. Students study the problem and analyze possible solutions.

Planning. The structure, functions, algorithm, and required components of the robot are determined.

Design and construction. Students create the mechanical and electronic structure of the robot.

Programming. The control algorithm and AI-based functions are developed.

Testing. The robotic system is tested in different conditions.

Analysis and improvement. Errors are identified and the system is improved.

Presentation and evaluation. Students present their project and explain the results.

For example, students can be assigned a project entitled “Designing an Intelligent Obstacle-Avoiding Robot.” During this project, students use sensors to collect information about the environment. The data are processed by the control system, and the robot makes decisions about movement. This activity requires students to combine knowledge of physics, electronics, programming, mathematics, and artificial intelligence.

Project-based learning also promotes teamwork. Students can perform different roles, such as programmer, designer, engineer, researcher, or project coordinator. This develops communication, cooperation, responsibility, and leadership skills.

CONCLUSION.The analysis conducted in this study demonstrates that the integration of artificial intelligence elements into robotics lessons has significant methodological and pedagogical potential. AI technologies enable students to move beyond traditional robotic programming and participate in the development of intelligent systems capable of analyzing information, recognizing objects, processing data, and making autonomous decisions.The use of artificial intelligence in robotics education contributes to the development of students’ computational thinking, algorithmic reasoning, engineering competence, creativity, critical thinking, and problem-solving skills. Project-based learning, problem-based learning, inquiry-based learning, and STEM-oriented approaches create favorable conditions for the effective integration of AI into the educational process.

The methodological effectiveness of AI-integrated robotics lessons depends on the systematic organization of educational activities. It is important to combine theoretical knowledge with practical projects, provide students with opportunities to experiment and test their ideas, encourage teamwork, and assess not only the final result but also the process of problem-solving and project development.The integration of AI elements also changes the role of the teacher. The teacher acts as a facilitator, consultant, and mentor who organizes a learning environment in which students independently explore technological problems and develop solutions. This approach increases students’ motivation and promotes the development of independent and creative thinking.

At the same time, the effective implementation of AI in robotics education requires appropriate technological infrastructure, methodological resources, teacher training, and age-appropriate educational content. Particular attention should also be paid to the ethical and responsible use of artificial intelligence.In conclusion, the integration of artificial intelligence elements into robotics lessons is an effective methodological direction for improving modern technology education. It provides opportunities for developing students’ technological, engineering, digital, computational, and creative competencies and prepares them for future professional activities in an increasingly digital and intelligent technological environment. Therefore, the systematic development and implementation of AI-based robotics teaching methodologies should be considered an important priority in the modernization of contemporary education.

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