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PEDAGOGICAL MECHANISMS OF USING ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE INDIVIDUALIZATION OF THE LEARNING PROCESS

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Abstract: The rapid development of artificial intelligence technologies has significantly transformed the contemporary educational environment and created new opportunities for improving the quality and effectiveness of teaching and learning. One of the most important directions in this process is the individualization of education, which focuses on considering students' individual abilities, interests, knowledge levels, learning needs, cognitive characteristics, and personal development opportunities. Traditional educational approaches often apply relatively uniform teaching methods and learning materials, which may not adequately address the differences among students. In this regard, artificial intelligence technologies offer innovative opportunities for organizing personalized educational activities, developing individual learning trajectories, adapting educational content, monitoring academic performance, and providing timely feedback. This article examines the pedagogical mechanisms of using artificial intelligence technologies in the individualization of the learning process. Particular attention is paid to adaptive learning systems, intelligent tutoring technologies, personalized educational resources, automated assessment, learning analytics, and AI-supported feedback. The article also discusses the pedagogical and psychological conditions necessary for the effective integration of artificial intelligence into educational institutions. The analysis demonstrates that artificial intelligence can contribute to improving educational outcomes, strengthening student motivation, developing independent learning skills, and creating flexible educational environments. At the same time, the effective application of AI requires teachers' professional supervision, digital competence, ethical responsibility, and the preservation of human-centered educational principles.

Keywords: artificial intelligence, individualization of education, personalized learning, adaptive learning, educational technologies, pedagogical mechanisms, intelligent tutoring systems, digital transformation, learning analytics, differentiated instruction, student development, educational process.

Introduction

The development of modern society is increasingly associated with digital transformation and the widespread introduction of innovative information technologies into various areas of human activity. Education is one of the most important fields experiencing substantial changes under the influence of digital technologies. The emergence and rapid development of artificial intelligence have created new possibilities for improving educational content, teaching methodologies, knowledge assessment, and the organization of students' independent learning activities. In the contemporary educational environment, the effective use of artificial intelligence is becoming an important factor in ensuring educational quality, increasing accessibility, and improving the management of teaching and learning processes.

One of the fundamental challenges facing modern educational institutions is the organization of instruction in accordance with the individual characteristics of students. Every learner possesses unique intellectual abilities, interests, educational needs, previous knowledge, cognitive characteristics, learning pace, and levels of motivation. Consequently, the application of identical educational methods and materials to all students does not always provide sufficient opportunities for realizing their individual potential. In some cases, students with higher levels of knowledge may experience insufficient intellectual challenges, while learners who have difficulties understanding educational materials may

require additional explanations, practical exercises, and individual pedagogical support. These circumstances demonstrate the necessity of introducing educational approaches that recognize individual differences and create favorable conditions for personal development.

Individualization of the learning process represents a pedagogical approach aimed at organizing educational activities according to students' individual characteristics, capabilities, interests, and developmental needs. Its primary purpose is to ensure that every student receives appropriate educational support and has the opportunity to achieve learning objectives according to their individual potential. This approach contributes not only to improving academic performance but also to developing independent thinking, creativity, responsibility, self-regulation, and lifelong learning competencies.

However, implementing individualization through traditional teaching methods requires considerable pedagogical resources. Teachers must identify students' educational needs, prepare differentiated assignments, monitor individual progress, evaluate learning outcomes, and provide appropriate feedback. When working with large groups of students, performing all these activities individually can become a complicated and time-consuming process. In this context, artificial intelligence technologies provide additional opportunities for improving pedagogical activities and making the educational process more flexible, systematic, and responsive to individual needs.

Artificial intelligence systems can analyze educational information, identify patterns in students' academic performance, determine areas of difficulty, recommend supplementary materials, and adapt the complexity of learning assignments. Such opportunities make it possible to develop educational environments in which the content, pace, and methods of instruction can be adjusted according to students' individual learning requirements. At the same time, artificial intelligence should not be regarded as a replacement for teachers. Rather, it should serve as an additional pedagogical instrument that supports professional teaching activities and improves the effectiveness of educational interaction.

The relevance of this research is determined by the growing importance of digital technologies in education and the necessity of developing scientifically grounded pedagogical mechanisms for using artificial intelligence in individualized instruction. The purpose of this article is to examine the theoretical and practical foundations of artificial intelligence application in the individualization of the learning process, identify its major pedagogical mechanisms, and determine the conditions required for its effective implementation in modern educational institutions.

Literature Review

The theoretical foundations of individualizing the learning process are closely connected with classical and contemporary approaches in pedagogy and educational psychology. Many researchers have emphasized that effective education should take into account students' individual abilities, cognitive development, educational needs, and social environment. One of the important theoretical contributions to this area belongs to Lev Vygotsky, whose sociocultural theory emphasizes the importance of interaction, developmental support, and the zone of proximal development. According to this theoretical approach, effective instruction should be organized in accordance with what students can accomplish independently and what they can achieve with appropriate assistance. This principle is particularly relevant to artificial intelligence technologies because intelligent educational systems can provide differentiated explanations, recommendations, and learning tasks according to students' current levels of knowledge.

Benjamin Bloom's concept of mastery learning also provides an important theoretical foundation for the individualization of education. His approach emphasizes that students can achieve educational objectives when they receive sufficient learning time, appropriate instructional materials, and corrective educational support. In contemporary educational environments, artificial intelligence technologies can contribute to the implementation of these principles by identifying knowledge gaps, recommending supplementary activities, and providing opportunities for repeated learning and assessment.

Howard Gardner's theory of multiple intelligences has also influenced the development of individualized educational approaches. His theoretical perspective emphasizes the diversity of human abilities and the importance of recognizing different forms of intellectual development. From a pedagogical point of view, this approach encourages teachers to employ various educational methods, instructional materials, and learning activities. Artificial intelligence technologies can facilitate the presentation of educational information through different formats, including written texts, visual materials, audio explanations, interactive exercises, and digital simulations. Nevertheless, individual educational support should be based on actual learning needs rather than rigidly assigning students to fixed learning-style categories.

The application of artificial intelligence in education has been extensively discussed in the works of Wayne Holmes, Maya Bialik, and Charles Fadel. In their book Artificial Intelligence in Education: Promises and Implications for Teaching and Learning, the authors analyze the opportunities and challenges associated with integrating AI into educational systems. They emphasize that technological innovation should be connected with clear pedagogical objectives and should contribute to improving the quality of teaching and learning rather than simply increasing the use of digital tools.

Rose Luckin and her colleagues have also examined the potential of artificial intelligence to support educational processes through intelligent analysis of student learning activities. Their research demonstrates that artificial intelligence can provide valuable information about students' educational progress and help teachers make more informed pedagogical decisions. In this context, AI technologies can contribute to understanding not only final learning outcomes but also the processes through which students acquire knowledge and develop competencies.

Research on intelligent tutoring systems represents another important direction in this field. These systems are designed to provide individualized educational assistance through explanations, questions, hints, and corrective feedback. By analyzing students' responses, intelligent tutoring systems can identify misunderstandings and offer additional instructional support. Such technologies are particularly useful in subjects that require sequential knowledge acquisition, regular practice, and systematic correction of errors.

Adaptive learning technologies have also become an important component of modern digital education. These systems use algorithms to modify the complexity, sequence, and presentation of educational materials according to students' learning performance. As a result, learners can progress through educational content at a pace that corresponds more closely to their individual knowledge levels and educational needs.

International organizations have also emphasized the importance of artificial intelligence in transforming education. UNESCO, in its publication Guidance for Generative AI in Education and Research (2023), highlights the importance of human-centered approaches, ethical responsibility, transparency, and personal data protection. The OECD has examined how digital technologies, including artificial intelligence, can contribute to the development of effective educational ecosystems. The European Commission has also developed recommendations concerning the ethical use of artificial intelligence and educational data in teaching and learning.

The analysis of these scientific and theoretical approaches indicates that the individualization of education and the application of artificial intelligence are interconnected areas of contemporary pedagogical development. However, the successful integration of AI technologies requires more than technical infrastructure. It also depends on the pedagogical competence of teachers, the quality of educational content, the responsible use of student data, and the development of students' independent learning abilities.

Discussion

The individualization of the learning process is an important pedagogical condition for ensuring the comprehensive development of students and improving the effectiveness of educational activities. Its essence lies in recognizing the individual differences that influence the acquisition of knowledge, the formation of competencies, and the development of personal characteristics. Students may differ considerably in their prior knowledge, intellectual abilities, attention, memory, thinking processes, interests, educational motivation, and learning pace. Therefore, organizing instruction exclusively through uniform educational methods may limit opportunities for some students to achieve their full potential.

Artificial intelligence technologies create new opportunities for addressing these challenges by providing additional instruments for the analysis and organization of educational activities. Through the processing of information about students' learning performance, AI systems can identify recurring mistakes, determine areas of difficulty, and recommend appropriate educational resources. This enables teachers to organize differentiated instruction more effectively and provide additional support to students who need it.

One of the most important pedagogical mechanisms of artificial intelligence application is diagnostic assessment. The diagnostic mechanism involves identifying students' initial knowledge levels, educational needs, individual difficulties, and learning progress. AI-supported diagnostic tools can analyze test results, written assignments, responses to educational questions, and patterns of interaction with digital learning platforms. Based on the information obtained, the system can identify areas in which students demonstrate insufficient knowledge and recommend additional learning activities. For example, if a student experiences difficulties understanding a particular theoretical concept, the system may recommend supplementary explanations, examples, and practical exercises. This process helps teachers obtain more detailed information about students' educational needs and organize appropriate pedagogical support.

Another important mechanism is adaptive learning. Adaptive learning technologies make it possible to adjust educational content, task complexity, and instructional recommendations according to students' individual performance. When students successfully complete learning assignments, the system can gradually introduce more complex educational tasks. Conversely, when students demonstrate difficulties, the system can provide additional explanations and exercises designed to strengthen their understanding. Such an approach contributes to creating a flexible educational environment in which students can acquire knowledge according to their individual learning pace. The pedagogical significance of adaptive learning is associated with maintaining an appropriate balance between the difficulty of educational tasks and students' existing knowledge and abilities.

The personalization of educational content is another important direction in the application of artificial intelligence. Modern AI systems can assist teachers in preparing educational materials that correspond to different levels of knowledge, educational interests, and instructional objectives. The same topic can be explained through short theoretical descriptions, detailed academic texts, practical examples, visual illustrations, interactive exercises, and problem-based learning activities. This makes educational information more accessible and creates additional opportunities for students to study complex topics in different ways. Teachers can also use generative artificial intelligence to prepare supplementary materials, develop questions, create practical situations, and formulate assignments according to students' educational levels. However, AI-generated materials should always be reviewed for academic accuracy, relevance, and pedagogical appropriateness.

The development of individual educational trajectories represents another significant pedagogical mechanism. An individual educational trajectory is a purposeful sequence of learning activities developed according to a student's initial knowledge, educational needs, interests, and expected learning

outcomes. Artificial intelligence technologies can assist in identifying the most appropriate sequence of educational topics and recommending supplementary learning materials. For instance, students studying pedagogical psychology may demonstrate different levels of knowledge in psychological diagnostics, developmental psychology, educational motivation, and interpersonal communication. AI-supported platforms can recommend additional educational resources in areas where individual students experience difficulties while providing more advanced materials to those who have already mastered the relevant topics. This approach contributes to the development of a more flexible and student-centered educational process.

The feedback mechanism also plays an important role in the individualization of education. Feedback provides students with information about their achievements, mistakes, and opportunities for improvement. Artificial intelligence systems can provide immediate responses to certain types of assignments and explain why particular answers are incorrect. They can also recommend additional exercises and learning materials based on students' performance. Timely feedback can contribute to strengthening educational motivation, improving understanding, and developing students' ability to monitor their own progress. Nevertheless, automated feedback should be supplemented by teachers' professional explanations, encouragement, and pedagogical guidance, especially when students encounter complex theoretical or practical problems.

Learning analytics represents another important mechanism for improving individualized education. This approach involves collecting, processing, and interpreting information about students' educational activities. Artificial intelligence can analyze test results, assignment completion, participation in digital learning platforms, time spent on educational activities, and recurring errors. The resulting information can help teachers understand patterns of academic progress and identify students who may require additional pedagogical assistance. However, educational analytics should be interpreted carefully because digital performance indicators cannot fully represent students' intellectual abilities, psychological characteristics, motivation, or personal circumstances.

Automated assessment technologies also provide additional opportunities for organizing individualized learning. Artificial intelligence can assist in checking objective test questions, identifying common mistakes, analyzing certain structured written responses, and preparing assessment reports. These functions can reduce teachers' routine workload and provide more opportunities for individual consultations and educational support. At the same time, the assessment of complex academic writing, creative assignments, ethical reasoning, and practical competencies should involve professional human evaluation. The final responsibility for important educational decisions must remain with qualified teachers.

The application of artificial intelligence in education is also closely connected with the development of students' psychological characteristics and independent learning competencies. Educational motivation, attention, memory, thinking, emotional stability, and self-regulation significantly influence the effectiveness of learning activities. AI-supported educational environments can contribute to maintaining students' engagement by providing tasks that correspond to their current knowledge levels and offering timely recommendations. When students receive appropriate educational support, they may develop greater confidence in their abilities and become more willing to participate in learning activities.

Another important outcome of AI-supported individualization is the development of self-regulated learning. This competency involves setting educational goals, planning learning activities, selecting appropriate resources, monitoring progress, identifying difficulties, and evaluating personal achievements. Artificial intelligence systems can support these activities through personalized recommendations and progress reports. However, excessive reliance on AI-generated answers may reduce students' independent analytical activity and problem-solving skills. Therefore, teachers should encourage students to verify information, compare different sources, formulate independent conclusions,

and use artificial intelligence as a supportive learning instrument rather than a substitute for intellectual effort.

The role of teachers remains central in the process of AI-supported individualization. Artificial intelligence can perform certain analytical and informational functions, but it cannot fully replace the professional judgment, emotional understanding, educational responsibility, and interpersonal communication of teachers. The teacher is responsible for determining educational objectives, selecting appropriate technological tools, interpreting the information provided by AI systems, evaluating the quality of educational materials, and organizing pedagogical interaction. Consequently, the introduction of artificial intelligence changes certain aspects of teachers' professional activities and increases the importance of their digital, methodological, and analytical competencies.

The effective integration of artificial intelligence into educational institutions also requires appropriate organizational and pedagogical conditions. Educational institutions should provide sufficient technological infrastructure, reliable internet access, and opportunities for professional development. Teachers should be prepared to use digital platforms, evaluate AI-generated information, and organize differentiated learning activities. Particular attention should be given to the protection of students' personal information, the transparency of algorithmic processes, and equal access to digital educational resources. Artificial intelligence should be implemented according to clearly defined educational objectives and should contribute to the development of an inclusive, accessible, and student-centered learning environment.

Despite its advantages, the use of artificial intelligence in education also creates certain risks. These include inaccurate information generated by AI systems, algorithmic bias, insufficient protection of personal data, unequal access to digital technologies, and excessive dependence on automated assistance. Such challenges demonstrate the importance of establishing clear institutional policies and maintaining continuous pedagogical supervision. Students should also develop AI literacy, which includes understanding the possibilities and limitations of artificial intelligence, evaluating the reliability of generated information, and using digital technologies responsibly.

Results

The theoretical analysis of scientific literature and pedagogical approaches demonstrates that artificial intelligence technologies can create favorable conditions for improving the individualization of the learning process. The analysis identifies several interconnected pedagogical mechanisms through which AI can contribute to more flexible and effective educational activities. These mechanisms include diagnostic assessment, adaptive learning, personalized educational content, individual learning trajectories, continuous feedback, learning analytics, and automated assessment support.

The findings indicate that diagnostic technologies can help identify students' initial knowledge levels and educational difficulties, allowing teachers to organize more appropriate pedagogical support. Adaptive learning systems can modify the complexity and sequence of educational assignments according to individual performance, thereby supporting students' progress at an appropriate pace. Personalized educational materials can expand opportunities for acquiring knowledge through different instructional formats, while individual educational trajectories can provide a more systematic approach to achieving learning objectives.

The analysis also demonstrates that AI-supported feedback and learning analytics can improve the monitoring of educational progress and contribute to the timely identification of learning difficulties. These mechanisms can support teachers in making more informed pedagogical decisions and organizing differentiated instructional activities. At the same time, the development of independent learning skills, critical thinking, and self-regulation remains an essential educational objective that should not be replaced by automated technological assistance.

On the basis of the theoretical analysis, it can be concluded that the effectiveness of artificial intelligence in individualized education depends on the integration of technological capabilities with pedagogical expertise. AI technologies are most effective when they are used to support clearly defined educational objectives, provide differentiated learning opportunities, and strengthen the interaction between teachers and students. The findings also emphasize that the introduction of artificial intelligence should be accompanied by appropriate ethical standards, personal data protection, teacher training, and continuous evaluation of educational outcomes.

The proposed pedagogical approach considers individualization as a continuous process that begins with the identification of students' educational needs and continues through the development of personalized learning activities, adaptive instruction, monitoring, feedback, and evaluation. Such an approach provides a theoretical foundation for organizing educational activities in accordance with individual student characteristics and creating more flexible learning environments.

It should be noted that the results presented in this article are based on theoretical analysis and systematization of scientific approaches. Therefore, the practical effectiveness of the identified mechanisms requires further empirical investigation through pedagogical experiments, student assessments, teacher observations, and comparative analysis of educational outcomes.

Conclusion

The individualization of the learning process represents one of the important directions in the development of contemporary education. It is based on recognizing the individual characteristics, educational needs, intellectual abilities, interests, and developmental opportunities of each student. The organization of effective educational activities therefore requires pedagogical approaches that provide appropriate learning conditions and support the realization of individual potential.

The analysis conducted in this article demonstrates that artificial intelligence technologies create significant opportunities for improving the individualization of education. Adaptive learning systems, intelligent tutoring technologies, generative artificial intelligence, educational analytics, automated assessment, and personalized feedback can support the organization of flexible and differentiated learning activities. These technologies make it possible to identify educational difficulties, recommend supplementary resources, adjust task complexity, and monitor individual progress.

The main pedagogical mechanisms of using artificial intelligence in the individualization of education include diagnostic assessment, adaptive instruction, personalized educational content, individual learning trajectories, continuous feedback, learning analytics, and automated assessment support. Their systematic application can contribute to improving the accessibility of educational materials, strengthening learning motivation, developing independent learning competencies, and increasing the effectiveness of pedagogical interaction.

In our opinion, the most important condition for the successful application of artificial intelligence in education is the integration of technological opportunities with the professional knowledge and pedagogical experience of teachers. Artificial intelligence should not replace human interaction or the educational responsibilities of teachers. Instead, it should serve as an additional instrument for improving the quality of instruction and supporting students' individual development.

At the same time, educational institutions should pay particular attention to the ethical use of artificial intelligence, the protection of personal information, the prevention of algorithmic bias, and the reduction of digital inequality. Students should be taught to use AI technologies critically, responsibly, and independently, while preserving their ability to think analytically and make informed decisions.

In conclusion, the purposeful and scientifically grounded implementation of artificial intelligence technologies can contribute to the development of a modern educational environment based on individual needs, differentiated instruction, pedagogical flexibility, and continuous personal development. Further research should focus on evaluating the practical effectiveness of AI-supported

individualization, developing appropriate pedagogical models, and identifying the most effective ways of integrating artificial intelligence into different levels of education.

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