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SYSTEMATIC OVERVIEW OF ARTIFICIAL INTELLIGENCE AND ITS APPLICATIONS IN THE EDUCATIONAL PROCESS

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Summary. *The article systematizes artificial intelligence technologies and identifies their application in education. This study is relevant because digital and artificial intelligence technologies are increasingly used in education. The goal is to organize artificial intelligence technologies and analyze their didactic potential. The paper summarizes scientific classification approaches and recommends using functional purpose, technological basis, and autonomy as criteria. Main types include generative models, adaptive learning systems, intelligent assessment systems, and educational data analytics, built on machine learning, deep learning, natural language processing, and computer vision. Findings show that artificial intelligence enables personalized learning, fosters critical thinking, improves formative assessment, increases interactivity, and supports teachers. The study concludes that using these technologies rationally increases educational effectiveness, supports individualized learning, and develops students' key competencies in a digital environment.*
Keywords: *artificial intelligence, educational technology, classification of artificial intelligence technologies, pedagogical potential, personalized learning, critical thinking, digitization of education.*

Statement of the Problem. The rapid development of digital technologies, along with the active implementation of artificial intelligence tools in public life, necessitates their integration into education. In today's digitalized educational environment, artificial intelligence technologies create new opportunities. They improve the organization of learning, increase its effectiveness, and help individualize students' educational paths. Intelligent systems can automate routine pedagogical tasks, analyze educational data, adapt content to learners' needs, and foster self-directed learning skills.

At the same time, the spread of various artificial intelligence tools demands scientific analysis and systematization. It is also necessary to identify their didactic uses within education. Studies present different ways to classify artificial intelligence technologies. However, generalizing these technologies and defining their pedagogical potential requires further analysis. Particularly relevant is exploring how artificial intelligence can personalize learning, develop critical thinking, increase interactivity, and support teachers' professional work.

Thus, this study is relevant because of the need to systematize artificial intelligence technologies and define their didactic potential for effective use in today's educational process.

Analysis of Research and Publicationsю Artificial intelligence technologies in education are a major focus in current academic literature. The field of Artificial Intelligence in Education (AIED) has grown with digital technologies, machine learning, and educational data analytics, which are changing traditional educational practices. Researchers examine how artificial intelligence can support learning and teaching. Current studies show that artificial intelligence is used in adaptive learning systems, intelligent assessment systems, virtual educational environments, and educational data analysis tools, helping improve learning quality and teaching effectiveness.

Research Objective. This article aims to systematize artificial intelligence technologies, identify their pedagogical potential, and justify their effective use in personalizing learning, developing students' critical thinking, and optimizing teachers' pedagogical activities.

To achieve this objective, the following tasks have been identified:

1. Analyze scientific approaches to artificial intelligence technologies in modern education.
2. Systematize artificial intelligence technologies.
3. Describe key types of artificial intelligence tools in education.
4. Identify ways artificial intelligence technologies support teachers' professional activities.

Presentation of the main material. In the rapidly evolving field of education, technology has become a decisive factor, and artificial intelligence (AI) has emerged as the primary catalyst for the sector's transformation. The convergence of pedagogy and technological innovation has given rise to a range of AI tools that are revolutionizing the learning process. The integration of artificial intelligence technologies into education necessitates their systematization and the identification of their pedagogical potential. Classifying AI tools in education can optimize learning and teaching processes, as studying and categorizing them helps identify their distinctive features, specific applications across various educational contexts, and their impact on learning effectiveness.

Classifying AI enables educators to consciously select tools aligned with educational goals and to foster students' critical thinking about the use of digital technologies [11].

In the studies by Russell and Norvig [13], it is reported that artificial intelligence is used to develop intelligent computer systems. On the other hand, Hinton [9] emphasizes that it revolutionizes the way students access information and interact with educational content to acquire key skills. Similarly, UNESCO [16] highlights the importance of using AI technologies to personalize the learning experience and adapt educational resources to students' individual needs, thereby promoting continuous and collaborative learning.

Artificial intelligence is advancing in collaboration with various industries because it can analyze complex social problems, identify difficult-to-detect causes, propose solutions, and make everyday life more convenient [3]. AI refers to computers that mimic human actions, such as thinking and learning. Some typical examples of such AI include IBM's Watson, DeepMind's AlphaGo, Apple's Siri (also known as a smart

assistant service), Google's Google Now, Samsung Electronics' Bixby, SKT's NUGU, and others. AI is evolving alongside advances in analyzing large volumes of accumulated data using cloud services [7]. Most of these data-driven AI services employ algorithms that enable machines to learn autonomously. An AI service formalizes human decision-making processes using various models and algorithms [12]. When a person makes a decision, they retrieve information related to a specific problem, examine various relevant knowledge and cases, and make a decision based on sound judgment. AI can analyze complex social problems to identify causes that are difficult for humans to detect and propose solutions; it can also bring convenience to everyday life, which is why it can evolve alongside various industries [8]. To use AI properly, it is necessary to understand how it works: how it classifies and processes information.

The classification of artificial intelligence technologies is a crucial stage in the scientific analysis of modern digital tools actively being integrated into education. The rapid development of artificial intelligence is driving the emergence of a wide range of technological solutions that differ in their functions, operating principles, complexity, and degree of autonomy. In this regard, there is a need to systematize these technologies, enabling a better understanding of their capabilities, areas of application, and potential impact on the educational process.

In the scientific literature, several approaches to classifying artificial intelligence technologies have been proposed. Various researchers propose grouping them according to specific characteristics depending on the research objective, functional capabilities, or technological basis (Fig. 1).

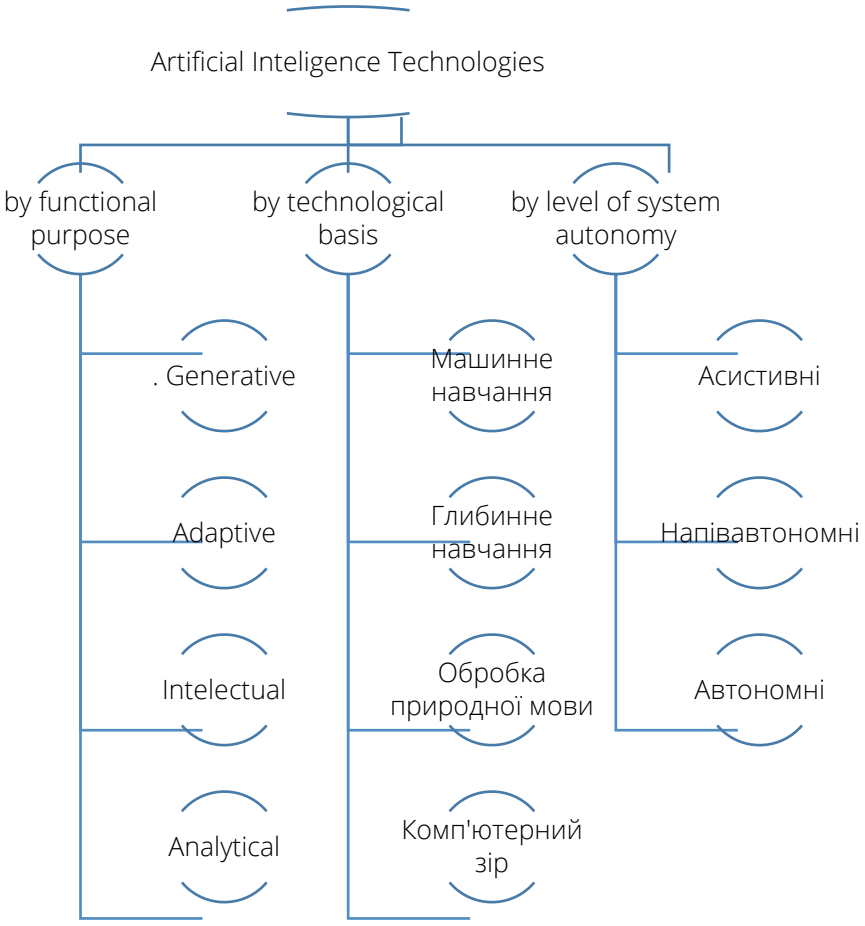

Fig. 1 A generalized classification scheme for AI technologies

The most common approaches involve classification by functional purpose, technological basis, and level of system autonomy. This approach allows a comprehensive examination of how artificial intelligence technologies function and helps determine their role in the modern educational environment.

Classification by functional purpose [18] involves categorizing artificial intelligence technologies according to the tasks they perform in the educational process. In this context, artificial intelligence can be used to create educational content, analyze students' learning activities, automate assessment, or support personalized learning. This approach enables the identification of the main areas of application for artificial intelligence technologies in education and understanding exactly what functions they can perform in interaction with teachers and students. Functional classification allows us to view artificial intelligence as a tool that facilitates the optimization of the educational process, enhances the effectiveness of educational activities, and fosters new forms of interaction among participants.

Another important approach is classifying artificial intelligence technologies by their technological foundation [19]. It is based on the analysis of algorithms, methods, and software solutions that underpin the operation of intelligent systems. This approach allows us to understand exactly which technological mechanisms ensure the functioning of artificial intelligence systems, how they process information, analyze data, and generate results. Examining technologies from this perspective enables tracing the evolution of artificial intelligence and identifying the main directions for its further improvement. Furthermore, analyzing the technological foundation contributes to a better understanding of the principles of intelligent systems and their potential capabilities in various fields of activity, particularly in education.

Equally important is the classification of artificial intelligence technologies by level of autonomy [15]. It reflects the degree of human involvement in the functioning of intelligent systems and the level of autonomy in their decision-making. In the modern educational environment, artificial intelligence technologies can play various roles—ranging from a supporting tool that assists the teacher to systems capable of independently analyzing information, generating recommendations, or partially automating certain educational processes. This approach allows us to determine how actively artificial intelligence technologies can influence the organization of the educational process and what role the teacher continues to play in this process.

Examining artificial intelligence technologies through the lens of their autonomy is also crucial for defining the limits of their use in education. Despite the significant technological capabilities of modern intelligent systems, humans continue to play a key role in the pedagogical process. It is the teacher who ensures the pedagogical appropriateness of technology use, monitors its results, and makes final decisions regarding the organization of educational activities. Therefore, classification by level of autonomy allows not only for the systematization of existing technologies but also for the identification of optimal models of interaction between artificial intelligence and humans in the educational environment.

Thus, classifying artificial intelligence technologies by functional purpose, technological basis, and level of autonomy allows for a comprehensive characterization of the diversity of modern intelligent systems and their potential for

use in education. This approach promotes a deeper understanding of the structure and capabilities of artificial intelligence technologies and lays the groundwork for further detailed analysis of each of the presented classifications.

Next, we will examine each classification in detail.

A. Classification by Functional Purpose

1. Generative models (creation of text, images, audio, and code)

Generative models are AI technologies that analyze large datasets to create new content. Rather than copying information, they generate original text, images, audio, or code in response to a prompt [4].

An example is OpenAI's work, specifically the ChatGPT model, which operates using large language models (LLMs) and natural language processing (NLP) technologies.

Generative models use deep learning and complex neural networks, especially transformer-based architectures. They analyze context and statistical patterns in large text datasets. During training, the models process this data to identify common linguistic structures, logical word relationships, and traits of different text types. This allows them not only to reproduce information but also to predict likely next statements based on context.

These models can continue a text on a given topic, change the style of expression, translate languages, summarize large amounts of information, and create structured educational content. Their technological foundation gives them broad didactic capabilities in education.

Generative models are powerful tools for modernizing education. Their didactic potential is realized not by replacing student activities but by organizing educational interaction. In this process, AI serves as support, analysis, and stimulation of thinking. Effective use depends on the teacher's pedagogical competence and fostering a responsible culture of digital technology use.

2. Adaptive Learning Systems

Adaptive learning systems are AI technologies that adjust the content, pace, and difficulty of learning tasks. They tailor changes based on a student's individual knowledge, progress, and needs. These systems analyze learning behavior, test results, task completion speed, and common errors [10].

Intelligent assessment systems are AI technologies for automating the analysis of students' knowledge, skills, and competencies. These systems use machine learning and data processing algorithms to grade assignments, provide feedback, and identify knowledge gaps [17].

These systems allow teachers to save time on routine grading and focus on instructional work and the development of students' critical thinking skills.

4. Learning Analytics

Learning Analytics are AI technologies for collecting, processing, and analyzing large sets of educational data. They use statistical analysis and machine learning to find patterns in students' learning activities, which helps inform pedagogical decisions.

The main goal of these systems is to turn data on the learning process—including attendance, test results, digital activity, and task completion—into insights for instructors and administrators. These insights help optimize the educational process.

B. By technological basis [1]

Based on its technological basis, AI is divided into:

- Machine Learning
- Deep Learning
- Natural Language Processing (NLP)
- Computer Vision

The technological foundation of artificial intelligence rests on several interconnected approaches. Machine Learning uses algorithms that learn from data and improve predictions without requiring programmers to make every decision. Such systems analyze large datasets, identify patterns, and draw conclusions. This ability allows automation in data classification, forecasting, and decision-making, especially in education and analytics.

Deep learning is part of machine learning and uses multi-layered neural networks for complex data analysis. These networks mimic the human brain, processing information through layers of abstraction. As a result, they recognize speech, analyze images or videos, identify objects, and find hidden patterns in large datasets. Deep learning powers high accuracy in content recognition and generation systems.

Natural Language Processing (NLP) enables human-machine interaction through text and speech. It helps systems understand message content, analyze context, generate responses, and translate texts. A practical example is ChatGPT, a conversational system by OpenAI. NLP lets users communicate in natural language and receive structured responses for various tasks.

Computer Vision focuses on recognizing and analyzing visual information. These systems identify objects, faces, and text in images. They also analyze scene characteristics. Applications include medicine, security, autonomous transportation, and educational technologies—for example, automatic analysis of educational materials or evaluation of students' visual work. Combining computer vision with other AI technologies further expands automated analysis and decision-making capabilities.

Machine learning, deep learning, natural language processing, and computer vision form the base of modern artificial intelligence. Their interaction lets systems analyze data, learn from experience, and perform intellectual tasks that once required humans. This brings new opportunities to education, science, and professions. However, it also requires responsible and methodologically sound use.

C. By level of autonomy [5]

- Assistive systems (teacher support)
- Semi-autonomous systems (partial decision-making)
- Autonomous systems (minimal human intervention)

Modern artificial intelligence technologies can be classified by their level of autonomy. This classification shows how independently a system can make decisions and interact with users.

Assistive systems support teachers in organizing learning, automating routine tasks, and preparing materials. They do not make independent decisions about assessment or managing the educational process, but serve as a tool for pedagogy.

Semi-autonomous systems can make some decisions based on data analysis, but humans retain final control. These systems may recommend actions, automate task assessment, or generate analytic conclusions for teachers to interpret and use.

Autonomous systems need minimal human intervention. They perform specific functions, make decisions, and adapt to changing conditions. In education, these systems analyze data, personalize learning, and automate assessment. However, their use demands pedagogical oversight and ethical regulation.

A major benefit of artificial intelligence in education is the chance for personalized learning. Modern pedagogy sees this as key to boosting educational effectiveness, since it addresses individual characteristics, preparation level, learning pace, and students' needs.

Artificial intelligence technologies expand the possibilities for personalized learning by analyzing large volumes of educational data and creating tailored learning paths.

One key aspect of personalized learning is adapting instruction pace to each student. Traditionally, everyone follows the same pace, which can challenge students who need more time or those who learn quickly. Artificial intelligence technologies analyze students' outcomes, test responses, completion speed, and other indicators of understanding. The system then suggests a personalized pace for modules, providing extra explanations or, for advanced students, more difficult tasks.

Another important aspect of personalization is selecting learning materials that align with students' individual learning styles. Students process information differently. Some learn best from text, while others learn best from visual or interactive resources. Artificial intelligence technologies address these differences by offering diverse content formats. For example, the system can review a student's previous activity to see what helps with retention. As a result, the student receives content in the format most effective for them. This boosts engagement and deeper mastery of material.

Personalized learning identifies and addresses individual knowledge gaps. Artificial intelligence reviews assignments, tests, and assessments to spot topics or skills students find difficult. The system then suggests targeted exercises, explanations, or materials to close those gaps. This allows students to focus on their weak areas to build a comprehensive understanding.

Using artificial intelligence for personalized learning improves instructor-student interaction. These systems provide instructors with aggregated data on student outcomes, strengths, and weaknesses. This enables better planning and tailored support. With these tools, artificial intelligence not only personalizes learning but also makes teaching more effective.

Using artificial intelligence opens new opportunities for personalized education. These technologies can analyze learning data, adjust the pace, select content based on individual traits, and identify knowledge gaps. As a result, they improve educational effectiveness and support deeper, more conscious mastery of the material.

In today's digital education landscape, developing students' critical thinking is especially important. This is considered a key 21st-century skill. Critical thinking includes analyzing information, assessing reliability, identifying logical flaws, drawing

conclusions, and making decisions. Artificial intelligence, especially generative models, now supports new approaches for building these skills in students.

Generative AI models can create text, images, code, and other content by analyzing large datasets. Their use in education brings new learning situations. Students need to analyze the information they receive more deeply. They must assess the reliability and validity of what AI generates. This builds an analytical approach and fosters critical thinking.

Teaching students to evaluate the reliability of information is essential when using generative models in education. AI-generated results may have errors or generalizations. Students learn to verify accuracy, compare with other sources, and judge logical consistency. These activities build a responsible attitude to information and help students critically assess various sources.

Generative models in education strengthen students' ability to verify sources. While using AI-generated materials, students learn to seek additional sources, assess the scientific or informational value, compare different views, and draw sound conclusions. This method encourages information literacy, which is vital for critical thinking today.

Using artificial intelligence in education supports academic integrity among students. Working with generative models teaches students to use materials properly, cite sources, and maintain ethical standards. The instructor's role is to encourage responsible AI use and to explain academic integrity principles.

In conclusion, generative artificial intelligence in education develops students' critical thinking. Analyzing information reliability, checking sources, and adhering to academic integrity standards foster independence and responsibility. It also helps with effective digital information work.

Artificial intelligence plays a key role in supporting formative assessment in education. Formative assessment systematically tracks student progress. It not only records learning results but also gives feedback for further improvement. Using artificial intelligence expands formative assessment, enabling quick analysis and individualized support during learning.

Instant feedback is a major advantage of artificial intelligence in formative assessment. Traditionally, students wait for graded results. Intelligent systems can review responses in real time and give immediate feedback. This helps students quickly spot mistakes and adjust their strategies for better learning. Prompt feedback also boosts motivation and encourages more active participation.

Automated error analysis enhances formative assessment with artificial intelligence. Modern systems not only check the correctness of answers but also analyze errors. From this, the system identifies common difficulties and problem topics. It can provide extra explanations or exercises. For instructors, this analytical data helps them adjust content and methods to students' real needs.

Repeated practice is an important benefit of using artificial intelligence in formative assessment. Intelligent systems offer various tasks for practicing skills and gradually raising difficulty. Students can redo these tasks, find mistakes, and improve results. This encourages independent learning and responsibility for performance.

Repeated tasks and instant feedback help students develop their reflective skills. By analyzing their own work, students assess their preparation, identify areas

for improvement, and plan their learning independently. Formative assessment with artificial intelligence improves learning quality and builds metacognitive skills.

In summary, artificial intelligence technologies in formative assessment enhance the educational process. Instant feedback, automated analysis, and repeated practice provide individualized assessment, fostering students' active engagement, self-monitoring, self-regulation, and improving overall educational effectiveness.

Artificial intelligence significantly increases learning interactivity and motivation. Interactivity is a key aspect of effective learning, involving active student participation and engagement with materials and instructors. Intelligent technologies introduce dynamic, practice-oriented activities that mirror real-world professional situations.

Educational simulations are key for interactive learning. Artificial intelligence can model situations reflecting real professional conditions, allowing students to make decisions, analyze outcomes, and try different solutions. Simulations foster analytical thinking, decision-making, and the practical application of knowledge while providing a safe environment to explore strategies without real-world risks.

AI-powered role-playing scenarios also increase learning interactivity. Students take on roles in simulated situations to better understand professional practice and social interaction. Artificial intelligence can serve as virtual dialogue participants, simulating diverse perspectives. This method builds communication, critical analysis, and decision-making skills, and helps students appreciate the practical significance of course material, boosting motivation.

Artificial intelligence-enhanced case studies are vital for interactive learning. The case method, common in modern education, builds analytical thinking and practical problem-solving. Artificial intelligence creates complex, changing cases based on student choices. Students analyze scenarios, evaluate outcomes, and draw conclusions. This supports analysis, critical thinking, and teamwork skills.

Artificial intelligence-driven simulations, role-playing, and case studies make students more engaged in learning. Interactive formats encourage active thinking, stimulate interest, and boost motivation. Students move from passive reception to active interaction, leading to deeper, conscious knowledge acquisition.

Enhancing interactivity with artificial intelligence technologies improves student motivation and educational effectiveness. Simulations, role-playing, and interactive cases make learning practice-oriented, engaging, and relevant, fostering competency development and active participation.

Artificial intelligence enhances student learning and supports teachers. With increasing information, complex programs, and rising instructional standards, teachers face more organizational and analytical work. AI can optimize these processes, reduce workload, and improve educational organization.

Automating routine tasks is a primary way artificial intelligence helps teachers. Grading tests, analyzing results, preparing standardized messages, and organizing materials take much of a teacher's time. Intelligent systems automate these jobs, freeing up time. For example, artificial intelligence can grade tests, analyze responses, generate reports, and provide group performance summaries. This lets teachers focus on teaching, creating new methods, and working closely with students.

Another important area of application for artificial intelligence technologies is assisting in the preparation of instructional materials. Modern intelligent systems can facilitate the creation of a variety of educational resources, including test questions, exercises, and instructional texts. Artificial intelligence also helps teachers create instructional materials. Modern systems enable faster creation of tests, exercises, texts, presentations, and interactive tasks. These tools increase variety and speed. Artificial intelligence customizes materials to skill levels, course specifics, or learning aims. This allows more personalized and effective learning. CAL systems can identify patterns in students' academic performance, pinpoint common mistakes, analyze trends in academic success, and predict potential difficulties in mastering the course material. The analytical information obtained enables instructors to plan the educational process more effectively, adjust the content and instructional methods in a timely manner, and provide students with the necessary pedagogical support [3].

In addition, the analytical capabilities of artificial intelligence technologies increase the objectivity of academic performance assessment. Automated analysis systems minimize the influence of subjective factors and provide a more accurate assessment of students' academic achievements. This objectivity contributes to greater transparency and fairness in the educational process.

Artificial intelligence supports teachers by automating routine tasks, aiding in material preparation, and analyzing learning outcomes. This optimizes educational organization and effectiveness, enabling teachers to focus on creative, innovative teaching and to improve student interaction.

A synthesis of approaches to classifying artificial intelligence technologies and an analysis of their pedagogical potential lead us to conclude that there are significant opportunities to use such technologies in the modern educational environment. Systematizing artificial intelClassifying and analyzing artificial intelligence technologies shows many ways to use them in education. Grouping them by purpose, technology, and autonomy helps define their educational role and plan for effective use. It involves specific pedagogical functions that intelligent technologies can perform in the educational process. At the same time, classification by technological basis enables an understanding of the technical principles underlying the functioning of artificial intelligence systems, among which machine learning, deep learning, natural language processing, and computer vision play a significant role. Classification by level of autonomy, in turn, reflects the degree of human involvement in the functioning of intelligent systems and allows them to be viewed as support tools, partially autonomous systems, or fully autonomous solutions [6].

An analysis of the didactic potential of artificial intelligence technologies demonstrates their ability to significantly expand the possibilities for organizing the educational process. The use of such technologies promotes personalized learning, the development of students' critical thinking, the improvement of the formative assessment system, increased interactivity in the educational environment, and motivation to learn. In addition, artificial intelligence technologies support teachers' professional activities by automating routine tasks, assisting in the preparation of instructional materials, and analyzing learning outcomes.

Thus, combining various approaches to the classification of artificial intelligence technologies and analyzing their didactic potential enables a comprehensive understanding of their potential for use in education. The integration of such technologies into the educational process contributes to modernizing the educational environment, improving the quality of learning, and developing important competencies in students necessary for effective performance in the modern information society.

Conclusions and Recommendations. Classifying AI tools is essential to promoting equity in education by ensuring all students, regardless of socioeconomic status or ability, can access high-quality resources. This classification empowers educators to integrate technology ethically and equitably. In education, AI is used to customize content to students' needs, simulate human feedback, and make learning more effective. Clarity about classification strengthens educators' strategies for equitable technology integration.

AI systems can analyze large volumes of data to identify learning patterns and provide recommendations that optimize education. This allows educators to adapt their teaching methods to create a more enriching educational experience. Looking ahead, integrating AI into education means leveraging technology to improve the quality and accessibility of learning. The ultimate goal is to prepare students for successful careers in a technology-driven world by anticipating challenges and adapting educational strategies accordingly. A proactive approach is essential to fully leverage AI's potential in transforming education.

Artificial intelligence technologies have significant educational potential, provided they are implemented in a pedagogically sound manner. Rather than replacing teachers, AI transforms their role—from a transmitter of knowledge to a facilitator and mentor. A rational combination of traditional and innovative methods supports the development of key 21st-century competencies such as critical thinking and digital literacy.

Future research should focus on developing models for integrating artificial intelligence into education and studying their impact on students' skills. The ethical use of AI and the maintenance of academic integrity in digital education also require further scientific analysis.

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СИСТЕМАТИЗАЦІЯ ТЕХНОЛОГІЙ ШТУЧНОГО ІНТЕЛЕКТУ ТА ЇХ ВИКОРИСТАННЯ В ОСВІТНЬОМУ ПРОЦЕСІ

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Анотація. *У статті розглянуто питання систематизації технологій штучного інтелекту та визначення можливостей їх використання в освітньому процесі. Актуальність дослідження зумовлена активною інтеграцією цифрових технологій у*

сферу освіти та зростанням ролі штучного інтелекту у модернізації навчального середовища. Метою дослідження є систематизація технологій штучного інтелекту та аналіз їх дидактичного потенціалу в сучасному освітньому процесі. У роботі узагальнено наукові підходи до класифікації технологій штучного інтелекту та запропоновано їх розгляд за трьома основними критеріями: функціональним призначенням, технологічною основою та рівнем автономності. Охарактеризовано основні типи інтелектуальних освітніх технологій, зокрема генеративні моделі, адаптивні навчальні системи, інтелектуальні системи оцінювання та аналітичні системи навчальних даних. Проаналізовано технологічну основу функціонування таких систем, що включає машинне навчання, глибинне навчання, обробку природної мови та комп'ютерний зір. Особливу увагу приділено дидактичному потенціалу технологій штучного інтелекту, зокрема їх можливостям щодо персоналізації навчання, розвитку критичного мислення студентів, удосконалення системи формувального оцінювання, підвищення інтерактивності освітнього процесу та підтримки професійної діяльності викладача. У результаті дослідження обґрунтовано, що раціональне використання технологій штучного інтелекту сприяє підвищенню ефективності освітнього процесу, створює умови для індивідуалізації навчання та формування ключових компетентностей студентів у сучасному цифровому середовищі.

Ключові слова: *штучний інтелект, освітні технології, класифікація технологій штучного інтелекту, дидактичний потенціал, персоналізація навчання, критичне мислення, цифровізація освіти.*