

ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ / ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ

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ADAPTIVE LEARNING SYSTEMS AND THE STRATEGIC ROLE OF ARTIFICIAL INTELLIGENCE

The article analyzes the key role of information technologies, particularly artificial intelligence, in transforming modern education by creating adaptive learning environments. The technological tools, pedagogical foundations, and operational mechanisms of such systems are examined, and their effectiveness is analyzed based on empirical data. Special attention is given to the challenges associated with implementing adaptive learning and the specifics of this process in Ukraine amidst the current crises.

У статті проаналізовано важливу роль інформаційних технологій, особливо штучного інтелекту, у трансформації сучасної освіти через створення адаптивних навчальних середовищ. Розглянуто технологічний інструментарій, педагогічні основи та механізми функціонування таких систем, а також проаналізовано їхню ефективність на основі емпіричних даних. Особливу увагу приділено проблемам, пов'язаним із впровадженням адаптивного навчання, та специфіці цього процесу в Україні в умовах сучасних криз.

Ключові слова: адаптивне навчання, інформаційні технології, штучний інтелект, персоналізація, навчальна аналітика, EdTech, цифрова трансформація освіти.

Modern education is undergoing a process of substantial transformation, thus moving from unified models to personalized learning ecosystems. The catalyst for this revolution is information technology, especially artificial intelligence (AI), which makes it possible to create and scale adaptive learning environments (ALE). These systems leverage technology to deliver a personalized learning experience tailored to each student's unique needs, learning preferences, and current knowledge level, continuously adapting the content and pace in real time [7]. This approach overcomes the limitations of the one-size-fits-all model, creating a more effective, inclusive and motivating experience. This topic is especially relevant for Ukraine, where the consequences of the pandemic and a full-scale invasion have exacerbated the problem of educational losses, turning the introduction of adaptive technologies into an opportunity and a strategic necessity [2; 4].

ALE is based on leading pedagogical theories, such as constructivism, which emphasizes the active construction of knowledge by the student, and the theory of the zone of immediate development. Technologies allow the implementation of these principles in practice: systems stimulate active cognition, dynamically change tasks, and constantly determine the “zone” of the student, providing individualized support for further development [2].

The analyzed sources emphasize the present development and the future possibilities of AI-powered adaptive learning systems in education. These sources emphasize the ability of such technologies to personalize learning, increase student engagement, and support educators in planning and assessment [5; 8]. Covering both general and specialized contexts (e.g., physical rehabilitation), the studies present real-world implementations across various countries, including Ukraine, and stress the importance of ethical guidelines for AI integration. Artificial intelligence is a key driver in transforming education toward a more learner-centered and flexible model [5].

The technology architecture of these systems consists of several core elements: AI acts as the central control unit managing overall operations; machine learning (ML) serves as the

personalization mechanism, analyzing data to anticipate learning outcomes; natural language processing (NLP) supports the creation of intelligent tutoring tools; and learning analytics (LA) is used to track and evaluate student performance data [4].

Numerous studies confirm the effectiveness of adaptive learning. According to meta-analyses, on average, students using AI-based learning platforms achieve 15% higher test scores and show 20% greater engagement than those using traditional approaches. Other research also indicates a 35% improvement in knowledge retention and a 34% increase in average performance when understanding key concepts. Technology has also effectively closed the attainment gap between the strongest and weakest students to 47%. Such a positive impact on engagement is explained by the fact that when students feel that the system “understands” their difficulties and helps them overcome them through personalized feedback, they feel more supported and confident [1; 2; 6].

The introduction of ALE fundamentally changes the role of the teacher. Technology frees up their time for more complex and creative work by automating routine tasks such as testing basic knowledge. There is a transition from the “sage on stage” model to the “guide nearby,” where the teacher becomes a mentor who uses data from analytical panels to provide targeted support and focuses on developing higher-order skills: critical thinking, creativity and teamwork. Studies show that the main success factor is not technology but the “instructor presence” – its active interaction with system data to improve teaching. However, the “paradox of involvement” also arises here: excessive optimization of the individual process can lead to social isolation, which emphasizes the irreplaceability of the teacher in facilitating group interaction [3].

The technology stack behind these systems consists of several key components: artificial intelligence serves as the central element that manages all operations; machine learning functions as the personalization tool, processing data to forecast results; natural language processing enables the development of intelligent tutoring systems; and learning analytics is used to gather and interpret information about student performance [4].

In conclusion, adaptive IT-driven learning is a powerful transformative force that creates a more effective, inclusive, and equitable learning experience [5]. By leveraging AI and data-driven personalization, these systems address diverse learning needs, bridge gaps in educational access, and foster engagement – proving particularly vital in contexts like Ukraine, where resilience and adaptability are paramount. However, technology alone is not a panacea; its success hinges on a human-centered vision prioritizing pedagogy, teacher agency, and student well-being. The goal is not to automate education but to augment it – using AI to amplify human potential, empower educators with actionable insights, and cultivate critical thinking and creativity in learners.

Ukraine’s experience exemplifies this balance. Faced with displacement and disruption, adaptive technologies have sustained learning continuity while reinforcing the irreplaceable role of teachers as mentors and facilitators. It underscores a universal lesson – when ethically designed and collaboratively implemented, AI-driven learning can transcend its technical function, catalyzing individual growth and systemic resilience. The future of education lies not in replacing human interaction but in designing ecosystems where technology and humanity coexist to unlock every learner’s potential.

REFERENCES

1. EdTech Adaptive Learning Platform. *Eightgen AI. AI Solutions for Business*. URL: <https://eightgen.ai/case-studies/case-study-7>
2. Hashim S.N.A. et al. AI-Driven Adaptive Learning Systems: Transforming Curriculum Delivery in Education. *Nanotechnology Perceptions*. 2024. 20(6). PP. 3952-3960. URL: <https://nano-ntp.com/index.php/nano/article/download/3703/2783/7035>
3. Johnson C., Sloan A. Adaptive Learning: Implementation, Scaling, and Lessons Learned. *Educause Review*. 2020. URL: <https://er.educause.edu/articles/2020/4/adaptive-learning-implementation-scaling-and-lessons-learned>

4. Komolafe O.O. et al. Current applications and outcomes of AI-driven adaptive learning systems in physical rehabilitation science education: A scoping review protocol. *PLOS One*. 2025. 20(6). <https://doi.org/10.1371/journal.pone.0325649>
5. Kugai K. AI-powered personalization: revolutionizing foreign language learning in pedagogical science. *Психолого-педагогічні проблеми вищої і середньої освіти в умовах сучасних викликів: теорія і практика* : матеріали VIII Міжнародної науково-практичної конференції (Харків, 20-21 березня 2024 р.). Харк. нац. пед. ун-т імені Г. С. Сковороди. Харків, 2024. С. 173-177. URL: <https://er.knutd.edu.ua/handle/123456789/26516>
6. Narne H. Intelligent E-Learning Systems: Machine Learning-Driven Adaptive Frameworks for Enhanced Engagement and Retention. *IJRAR*. 2021. 8(4). PP. 390-395. URL: <https://www.ijrar.org/papers/IJRAR21D2534.pdf>
7. Кугай К.Б. Розуміння змісту і сутності поняття «персоналізація навчання іноземних мов» у зарубіжній науковій літературі. *Щомісячний науково-педагогічний журнал «Молодь і ринок»*. 2024. №1(221). С. 92-96. <https://doi.org/10.24919/2308-4634.2024.294265>
8. Рекомендації щодо відповідального впровадження та використання технологій штучного інтелекту в закладах вищої освіти. *МОН*. 2025. URL: <https://mon.gov.ua/static-objects/mon/sites/1/news/2025/04/24/shi-v-zakladakh-vyshchoi-osvity-24-04-2025.pdf>