

International Academy of Applied Sciences in Lomza
Institute of Pedagogy of NAES of Ukraine

DIGITAL TRANSFORMATION OF EDUCATION: CHALLENGES AND PROSPECTS

Monograph

Editorial Board:

**O. Topuzov,
M. Holovko,
I. Tverdokhlib,
Z. Sharlovych,
K. Ladonia**

Lomza – Kyiv

Wydawnictwo: MANS w Łomży – 2025

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The monograph has been prepared based on the results of the International Scientific and Practical Conference held in April at the Dragomanov Ukrainian State University, in cooperation with scholars from the Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine and the International Academy of Applied Sciences in Lomza.

The first chapter provides a detailed overview of modern digital technologies applied in educational and communication processes. The second chapter, devoted to digital and informatics education, skillfully combines the analysis of domestic and international experience, thereby contributing to the search for new ways of effectively integrating digital tools into the educational process. The third chapter describes contemporary aspects of STEAM education and educational robotics. The fourth chapter focuses on the use of artificial intelligence in education, highlighting not only the current state of technological development but also outlining potential ethical and methodological challenges that bring forward further academic discussion.

The systematization of examples and the analysis of their practical significance make this material valuable for researchers, university lecturers, and educators. The presented content is practice-oriented, thus opening broad prospects for its application in the educational process at institutions of various levels



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 At the present stage of development of society and education, the use of artificial intelligence (AI) technologies is gaining special importance. Due to the increasing digital transformation of all spheres of life, the education system is facing the need to adapt to new challenges that require a fundamentally new approach to the processes of teaching, assessment, management and formation of key competencies of students. In this context, the concept of Education 4.0, proposed by the World Economic Forum, is becoming increasingly important as a strategy for preparing students for the future, aimed at developing global citizenship, creativity, technological and social competence.

Artificial intelligence technologies, in particular generative models such as LLM (Large Language Models), have a powerful potential to transform the educational environment. However, their implementation is associated not only with opportunities,

but also with numerous challenges that require system analysis, research and strategic planning. The main challenge is how to effectively integrate AI into educational practice in a way that not only improves the quality of learning but also preserves the human factor, ethical standards, equality of access, and pedagogical integrity.

The purpose of this section is to provide a scientific analysis of the opportunities and limitations of using AI technologies in education, taking into account relevant examples, theoretical recommendations, and practical cases.

Overview of current research. In recent years, leading international scientific journals have been actively researching the use of AI technologies in education. While at the initial stage, researchers focused mainly on the automation of routine tasks and the use of chatbots, in recent years, there has been a growing interest in more complex systems that can adapt learning content to the needs of a particular student (Zawacki-Richter et al., 2023). Scopus and Web of Science publications for 2022-2025 show a trend towards the integration of AI not only in teaching, but also in the administration of the educational process, management of educational systems, and knowledge quality assurance (Siemens & Baker, 2022).

Studies by international organisations are of particular importance. For example, UNESCO (2023) emphasises that the effectiveness of AI in education depends on national digitalisation strategies and the development of ethical standards. The OECD (2024) emphasises that AI can support teachers but cannot replace them, and therefore the key task is to train teachers to work with intelligent systems. The World Bank (2023) draws attention to the potential of AI in the field of education management, in particular in crisis situations, which is especially relevant for countries experiencing military conflicts.

An important area of current research is the analysis of inclusiveness. AI can provide personalised support for students with special needs, as evidenced by publications in Computers & Education (Smith & Lee, 2023) and Educational Technology Research and Development (Chen et al., 2024). Thus, the review of scientific papers shows the multidimensionality of the problem, which covers pedagogical, managerial, social and ethical aspects.

Global challenges of modern education. Education systems face numerous challenges that hinder their ability to respond to the demands of the times. First and foremost, there is a global shortage of teaching staff, which is worsening in many regions, especially in sub-Saharan Africa. According to UNESCO's forecasts, more than 44 million more teachers will be needed by 2030 to ensure that the Sustainable

Development Goals are met, in particular Goal 4 - access to quality education for all. This issue is acute not only in developed economies, but also in countries where education remains inaccessible to a large number of children.

Along with the shortage of teachers, inefficient administrative processes and flawed assessment systems are also important challenges. Many countries face the fact that a significant portion of a teacher's time is spent on nonpedagogical tasks such as paperwork, attendance, grading, etc. In the United States, for example, the average weekly workweek for a teacher lasts 54 hours, of which only 46% is spent directly on teaching. In OECD countries, on average, only 44% of the time is spent in direct contact with students, which leads to a loss of teacher motivation, high levels of fatigue and professional burnout.

Another significant problem is the digital divide, which is increasingly separating certain groups of people from the opportunities of modern education. Even the most advanced technologies will only be effective if they are accessible to all. Currently, more than 2.6 billion people do not have basic access to the Internet, which automatically excludes them from the process of receiving education through digital tools. It's also worth considering that only 30% of AI specialists are women, which indicates a gender inequality in the technology sector that can affect the educational space as well.

Ukraine, like many other countries, also faces similar challenges. The shortage of teachers, low salaries, limited access to digital resources, and low digital literacy among teaching staff all require urgent action. That is why the introduction of artificial intelligence technologies should not be just a technical solution, but part of a broader educational policy focused on real transformation.

The methodology for analysing the use of AI in education is based on a combination of several approaches. The theoretical and analytical method was used to study modern publications, educational standards, and regulations. This made it possible to identify the main trends in the introduction of technologies and assess their compliance with the requirements of educational systems in different countries.

Empirical methods include surveys of teachers and students to assess the level of readiness of educational communities to use AI (Ivanova, 2022). Observations of AI implementation practices in universities and schools show that success depends not only on the availability of technological solutions but also on organisational culture and teacher training (Peterson & Wong, 2023).

The comparative method allows comparing international and national experience, identifying common patterns and differences. In particular, adaptive platforms are

widely used in the EU, while similar initiatives are at the stage of pilot projects in Ukraine (Kovalchuk, 2024). A predictive approach is used to model possible scenarios of education development under the influence of AI, which allows us to assess the potential implications for educational policy and practice.

International experience shows that countries with developed strategies for the digitalisation of education achieve significant results in the use of AI. For example, in Finland, the course «Elements of AI» has become mandatory in many universities and has contributed to the formation of digital literacy among the general population (Salmi, 2023). Estonia has integrated AI into educational information systems, which has made it possible to predict staffing needs and track student performance (Laar et al., 2022). In Singapore, adaptive educational platforms are actively used to individualise learning, and in the US, AI is becoming widespread in inclusive education, providing support for students with special needs (Brown & Davis, 2023).

For Ukraine, the experience of these countries is extremely valuable. In the context of martial law and the restoration of the educational system, AI can become a tool to ensure access to education for internally displaced persons, support distance and blended learning. Pilot projects of Ukrainian universities show that AI helps to adapt educational programmes to the needs of students and improve the efficiency of educational process management (Shevchenko, 2023). At the same time, the integration of AI in Ukraine requires solving the problems of financing, training, and creating a regulatory framework.

AI as a tool for education reform

New technologies, such as large-scale language models (LLMs), have the potential to automate a number of administrative tasks that traditionally take up a significant portion of a teacher's time. According to a study conducted by Accenture, approximately 20% of the time spent on clerical and organisational tasks can be automated using AI. This makes it possible to free up time for tasks that require human interaction, such as psychological support for students, individualised learning, motivation, and the development of social intelligence.

In addition, AI can enhance the role of the teacher instead of replacing it. For example, intelligent systems can analyse test results, provide instant feedback, offer differentiated tasks, and assist teachers in lesson planning. Studies have shown that in November 2023, 42% of teachers in the UK used generative AI models to prepare materials for classes, compared to 17% in April of the same year, which indicates a rapid growth in interest in these tools.

However, despite the potential benefits, it should be borne in mind that humans remain the central element of the educational process. Only a teacher can establish emotional contact with a student, understand their inner state, and create an atmosphere of trust and motivation. Therefore, AI integration should be aimed at supporting rather than replacing teachers. It is necessary to develop clear mechanisms that will ensure effective cooperation between humans and algorithms.

The use of AI in education opens up prospects for individualising the learning process, automating assessment, improving management efficiency, and supporting inclusiveness. For Ukraine, the use of AI in the post-war reconstruction of the educational system is a promising area. This applies to both the development of new educational programmes and the creation of intelligent management systems capable of ensuring transparency and accountability.

Integrating AI into the teacher training system is also of practical importance. Developing teachers' digital competencies is a key to the effective use of technology in the classroom. Moreover, research on the impact of AI on student motivation and results is promising, which will allow to justify educational policy and investments in this area.

Personalisation of learning

One of the most important advantages of using AI in education is the ability to personalise the learning process. Research, including that conducted by the World Economic Forum, shows that personalised learning supported by intelligent systems can significantly improve student outcomes. An example of this is the Letrus project in Brazil, where the introduction of an AI-based system to analyse students' texts and provide instant feedback led to a significant improvement in the results of the programme participants. In schools in the state of Espirito Santo, students achieved second place in national exams in literary analysis within five months of the project, while the control group was only eighth. This example shows that AI can not only analyse academic achievements but also identify problem areas, offer remedial tasks, and track the progress of each student. Algorithms can change the complexity of the material, taking into account the learning style, the pace of learning, and the individual's strengths and weaknesses. Thus, technology allows us to implement one of the key principles of Education 4.0 - personalised and independent learning that meets the needs of modern society. This creates the basis for flexible, adaptive learning environments where each student receives an individual development trajectory, which contributes not only to improving academic results but also to developing motivation, self-regulation and critical thinking.

Improving the education assessment and analytics system

Another important area of AI implementation in education is the improvement of the assessment system. Traditional assessment methods are often ineffective due to their standardisation, lack of prompt feedback, and limited consideration of individual student characteristics. As noted in the World Economic Forum's report (2024), many education systems conduct comprehensive assessments only once a year, which does not allow for timely identification and response to knowledge gaps. Generative models and machine learning can change this by enabling continuous assessment, real-time data analysis, and prediction of learning outcomes. This approach allows us to move from occasional testing to continuous monitoring of each student's progress, which is a key element of the Education 4.0 concept. Of particular importance is the use of AI to analyse non-standard forms of assessment, such as essays, projects, and research tasks. For example, in one case study, teachers worked with algorithms to create sample comments that AI subsequently used to analyse students' work. This ensured not only an objective assessment but also an individual approach, which helped to increase student motivation. For example, an AI-based system can detect that a student consistently makes mistakes in argumentation and offer targeted exercises to eliminate them. In addition, the use of AI allows education systems to obtain real-time analytical data, which can serve as a basis for making management decisions. School leaders, ministries of education, researchers - all these entities can receive detailed reports on student performance, identify trends, and plan investments in educational programmes. This approach ensures systemic accountability, transparency, and efficient use of resources. In a pilot project in the UAE, where an AI tutor was used, the time for checking assignments was reduced from several days to several minutes, which significantly increased the efficiency of feedback. Thus, AI is transforming assessment from a formal procedure into a dynamic, information-rich process aimed at supporting learning, not just assigning grades.

Building digital and AI literacy

One of the main areas of education reform in the context of technological development is the inclusion of AI in the curriculum. The issue is not that all students should become specialists in artificial intelligence, but rather that they should consciously use technology, understand its nature, be able to think critically about the use of artificial intelligence, recognise false information and analyse ethical implications. It is important to develop students' ability to distinguish between tools that truly enhance learning from those that can cause manipulation or spread misinformation

(UNESCO, 2024). Thus, the integration of AI into curricula is not limited to technical aspects, but also involves the development of media literacy, information culture, and social responsibility. In this section, we will give an example of the Pensamiento Computacional IA programme in Uruguay, where teachers are taught to integrate elements of computational thinking into different subjects - mathematics, language, and science. The programme also aims to combat gender inequality in technological education, which is one of the most pressing challenges in the modern educational environment (OECD, 2023). Particular attention is paid to the development of teaching materials that take into account the diversity of social groups and the creation of an educational space where every student can realise their potential regardless of gender or social background. As part of this programme, students learn how machine learning models work, how data is analysed, and how bias can occur in algorithms. They learn to critically analyse the decision-making process of algorithms, recognise the risks of discrimination, and understand why transparency and explanation of AI results are necessary. This fosters responsibility in the use of AI, which is a key stage in preparing young people for the digital economy. In addition, students acquire practical skills in working with data sets, developing simple models, and conducting experiments, which helps develop their scientific thinking and prepares them for future professional activities in a world where artificial intelligence is becoming an integral part of most industries (World Bank, 2023).

Integrating AI into educational materials

Another important aspect is the creation of accessible, personalised learning materials. A report at the World Economic Forum cited the example of the UNICEF initiative aimed at creating accessible digital textbooks (ADT). These textbooks are based on the principles of universal design for learning (UDL) and allow for the adaptation of educational material to the needs of different categories of students, including children with disabilities. As part of the ADT project, more than 500,000 digital textbooks have been introduced to schools in sub-Saharan Africa and Latin America, which can be used offline, especially in regions with limited Internet access.

These textbooks include:

- audio and video materials;
- sign language translation
- text synthesis;
- interactive tasks;
- adaptation of content to different formats.

Research conducted by UNICEF partners has shown that the use of such textbooks significantly increases student motivation, integration into the learning process and learning outcomes. This is a strong argument in favour of scaling up such technologies worldwide.

Developing digital skills and cybersecurity

In the context of the growing use of AI in education, it is important to pay attention to preparing for the safe use of technology. Grok Academy's research in

Australia and New Zealand has shown that digital literacy is not only the ability to use tools, but also the ability to understand the risks associated with the use of algorithms, processing of personal data, and the spread of misinformation.

Grok Academy's cybersecurity education programme has reached more than 91,000 students, including a significant number of girls, helping to close the gender gap in this area. The programme includes:

Cryptography courses;

- digital threat analysis;
- studying the impact of AI on society;
- developing critical thinking about the use of technology.

The results of the study showed that the students who participated in the programme had a much better understanding of the risks associated with the use of AI and actively used the knowledge gained in their further studies and professional activities. This once again confirms the importance of including an ethical aspect in educational programmes aimed at developing digital skills.

Practical examples of AI implementation in education (Table 1.1)

AI tutors and virtual assistants

The Kabakoo Academies programme in West Africa is an example of how AI-powered virtual tutors can significantly support students in their learning process. This initiative offers personalised learning based on interaction with a virtual tutor who can

- provide instant feedback
- analyse students' work
- provide recommendations;
- engage in dialogue in the learner's native language (including minority languages).

In Mali, for example, a model is being developed that provides learning in Bambara, the most widely spoken language in the country. This approach ensures inclusivity, personalisation and social justice, which are key features of the education of the future.

STEM education and creativity development

Another example of AI implementation is the 3D Africa for Girls project implemented by the Youth for Technology Foundation in Nigeria. This initiative offers girls aged 10 to 18 years old the opportunity to learn basic STEM skills (science, technology, engineering, mathematics) using 3D printing, programming, design, and entrepreneurship.

The project has demonstrated high efficiency:

- over 90% of participants continued their studies at higher education institutions;
- over 85% chose a career in the technology sector;
- over 90% of participants achieved a level of proficiency of 95% or more in basic and advanced digital skills.

This experience shows that technology has not only educational, but also emancipatory potential, especially in conditions where traditional avenues of social growth are limited.

AI in the fight against inequality in education

The JA Europe programme is implementing a curriculum that combines entrepreneurship and AI to teach young people how to solve the world's most pressing problems. The programme covers 10 countries and aims to train 30,000 young people over two years.

A special feature of this initiative is the integration of AI into rural and remote regions where access to technology is limited. The programme uses an interactive platform that allows students to:

- develop business plans
- learn to analyse data
- work in teams;
- apply AI in real-life situations.

In addition, the focus on supporting disadvantaged schools and refugees from Ukraine demonstrates that technology can be a tool to reduce social inequality rather than exacerbate it.

Innovative approaches in the face of limited resources

One of the most interesting examples of innovative educational practices in countries with relatively limited resources is the Ceibal initiative in Uruguay. It is known as a comprehensive programme for the digitalisation of education that combines technical infrastructure, pedagogical support, and the development of digital competencies. An important component of the programme was to train teachers

not only in the technical aspects of working with artificial intelligence, but also in the ethical use of algorithms, data analysis methods, and the recognition of bias in information flows (OECD, 2023).

The key goals of implementation can be summarised as follows:

- to ensure equal access to education with AI elements, regardless of the social or economic status of students;
- to develop data analysis competences that become the basis for participation in the digital economy;
- teach students to use technology ethically, which is especially important in the context of the spread of disinformation and automated decisionmaking systems (UNESCO, 2024).

The results of the programme confirm its effectiveness. In particular, the participation of students who studied under the initiative in the international Bebras competition showed a significant increase in their results compared to control groups. This indicates not only an increase in technical skills, but also the development of critical thinking and the ability to apply the acquired knowledge in practice (World Bank, 2023). Thus, Uruguay's experience demonstrates that even in countries with limited resources, it is possible to create effective innovative models for preparing students for life in a world where artificial intelligence technologies play a key role.

AI texts and digital textbooks

As part of the educational reform strategy, South Korea is planning to introduce AI textbooks starting from the 2025-2026 academic year. These textbooks should be adapted to different levels of knowledge, learning pace, and perception peculiarities. They will be used in mathematics, English, computer science, and later other subjects, except for practical disciplines such as music, physical education, and fine arts.

The systematic implementation includes:

- pilot testing among 400 teachers;
- analysis of effectiveness;
- scaling up based on the experience gained.

One of the goals is to reduce the workload of teachers, increase access to education, and create a culture of lifelong learning. A special place is given to the co-operation between a teacher and an AI assistant, which ensures a balance between technological capabilities and the human factor.

AI tutors and individualised learning

The United Arab Emirates has launched a pilot version of an AI tutor that offers

- individualised tasks;
- instant feedback
- analysis of students’ progress;
- multilingual support;
- detailed reports for parents and teachers.

The pilot showed a 10% improvement in academic performance, which is a significant achievement for the testing period. This tool is expected to help not only improve the quality of education, but also reduce dependence on private tutors, who are unaffordable for most families.

Table 1.1.

Examples of AI implementation in education

Country	Project	Objective
Brazil	Letrus	Personalised reading and writing
Uruguay	Ceibal	Computational thinking and AI education
Ukraine	Pilot projects in KPI	Student evaluation
United Arab Emirates	AI Tutor Project	Implementation of an intelligent tutor
Korea	AI-powered digital textbooks	Personalisation of learning
Australia	Grok Academy	Cybersecurity and digital literacy

Risks, limitations, and ethical issues

Despite the obvious benefits, the introduction of AI in education is accompanied by numerous risks that need to be considered. Among them:

- Privacy violations: collecting large amounts of data about students can raise concerns about the use of personal information;
- Changing the role of the teacher: there is a growing risk that teachers will lose their central role in the learning process;
- Increased inequality: lack of access to technology may further widen the educational gap;
- use of AI for cheating: there is a growing number of cases when students use AI to write homework, which violates the principles of academic integrity;
- ethical dilemmas: algorithms may have biases that affect equality of opportunities.

The integration of AI into education is accompanied by some other important risks. Firstly, there is a threat to academic integrity, as AI tools can be used to automatically complete assignments for students (Johnson, 2023). Second, there is a risk of increasing digital inequality between countries and institutions with different levels of resources (UNESCO, 2024). Third, the issue of personal data protection is relevant, as AI-based educational platforms collect large amounts of information about users (OECD, 2024).

It should be noted that 61% of respondents believe that they are not ready to trust AI, and 71% are worried about the risks associated with the use of these technologies. This indicates the need to create an ethical code of conduct for the use of AI in education, introduce standards of algorithm transparency, data protection, and guarantee equal access.

Ethical aspects also include the transparency of algorithms and the prevention of discriminatory practices. In Canada, special working groups have been established to develop recommendations for the responsible use of AI in education (Taylor, 2022). These examples demonstrate the importance of developing national policies that take into account the ethical dimension of technological innovation.

Necessary conditions for successful integration of AI in education

Based on the analysis of the experience of the countries presented in this section, we can identify five key conditions that must be met for the effective integration of AI in educational practice:

- **Collaboration with teachers:** any technology should be developed together with teachers so that it can meet the real needs of the educational process rather than formal standards.
- **Data protection and transparency of algorithms:** it is necessary to ensure transparency in the work of AI, use only the necessary data, anonymisation of personal information, and mandatory consent to data processing.
- **Financial support and independent expertise:** to scale technologies, it is necessary to create funding models, independently test AI products, and implement them only after confirming their effectiveness.
- **Teacher training:** teachers should be trained to work with intelligent systems, taught to be critical of algorithms, and to use AI as a tool, not a replacement.
- **Focus on equity and inclusion:** it is necessary to ensure access to AI education for all, taking into account the specifics of regions, the capabilities of children with disabilities, cultural and linguistic features.

Artificial intelligence technologies open up new horizons for the development of education, enabling personalised learning, automated assessment, digital literacy, and increased accessibility of education. At the same time, their implementation is accompanied by numerous challenges that require a systematic approach.

- AI has a powerful potential to transform education through personalisation, automation, and analytics.
- The introduction of AI technologies into educational practice should be regulated, taking into account ethical, legal and social aspects.
- Ethical and legal standards for the use of AI in education should be developed.
- Educational institutions should actively prepare teaching staff to work with intelligent systems.
- It is promising to develop a hybrid learning model where AI complements rather than replaces the human factor.

Thus, artificial intelligence technologies are a powerful catalyst for change in education. However, the successful implementation of these tools requires a clear strategy, interaction of all parties to the educational process, social justice and ethical use of technology.

Further research could be aimed at:

- developing methodological recommendations for the use of AI in specific subject areas;
- long-term analysis of the effectiveness of AI implementation in education;
- studying the impact of AI on the formation of critical thinking;
- studying the effectiveness of hybrid learning models using AI;
- development of international standards for the use of AI in education.

It is especially important to study the impact of AI on pedagogical ethics, the formation of academic culture, and the development of digital literacy among teachers and students. Only through comprehensive scientific research can a balance between innovation and educational goals be achieved.

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