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Digital transformation of education: challenges, opportunities, and development strategies in the context of global crises

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ABSTRACT

The author examines the digital transformation of education in the context of global crises, including the COVID-19 pandemic and military conflicts, which accelerate the introduction of digital technologies into the educational process. The main challenges of digitalization, including the digital divide, technical support of educational institutions, the level of digital literacy of teachers and students, and the preservation of the humanitarian aspect of education, are explored.

The article analyzes the opportunities offered by digital transformation to improve the quality of education. The author explores the role of cloud technologies, artificial intelligence, virtual and augmented reality, and adaptive learning platforms in personalizing the educational process. The international experience of digital transformation, in particular European approaches to the introduction of innovative educational technologies, is considered.

The author substantiates the need to create a comprehensive strategy for the digital transformation of education, which includes improving the regulatory framework, providing teachers with methodological support, raising the level of digital competence, and developing common standards for assessing the effectiveness of digital learning. Recommendations are offered to overcome the main barriers to digitalization and ensure the availability of quality education in times of crisis.

Thus, the study demonstrates the importance of integrating digital technologies into the educational process, taking into account both technological and socio-psychological aspects. The strategic directions for the development of digital education that contribute to its sustainability and efficiency are identified.

KEYWORDS: digital transformation, education, global crises, digital literacy, adaptive learning, artificial intelligence, educational technologies, innovations.

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1. Formulation of the problem. The modern education system is facing the need for a profound transformation driven by the rapid development of digital technologies and global challenges such as the COVID-19 pandemic and the full-scale war in Ukraine. Although digitalisation of education is recognised as a key tool for improving the quality and accessibility of education, its implementation is accompanied by a number of contradictions. On the one hand, digital technologies open up new opportunities for personalising learning, developing critical thinking, and making the educational process more flexible (Hudzenko, 2024). On the other hand, there are serious challenges associated with the digital divide, insufficient technical equipment of educational institutions and low levels of digital literacy among teachers.

One of the key problems is the lack of a unified digital transformation strategy that would take into account the specifics of the Ukrainian education system. Research shows that many educational institutions implement digital tools in a fragmented manner, without a clear understanding of their place in the educational process. This leads to the fact that innovations often remain superficial and do not have the expected effect. In addition, there is a gap between theoretical developments in the field of digital education and their practical application, due to a lack of methodological support and insufficient funding.

Another important problem is the psychological readiness of participants in the educational process to change. Studies show that many teachers and students are not ready for a full transition to digital formats due to fear of new technologies, lack of motivation, or insufficient digital skills. This creates additional barriers to the effective integration of digital tools into the learning process.

Another significant challenge is preserving the humanitarian component of education in the context of digitalisation. The active introduction of technology can lead to a loss of personal contact between teachers and students, a diminished role for socialisation in the educational process, and excessive technocratisation of learning. At the same time, modern challenges, such as distance learning during the war, require rapid adaptation to digital formats, which makes this problem particularly relevant.

In addition, there is a need to develop effective mechanisms for assessing the quality of digital education. Currently, there are no uniform standards that would allow measuring the real impact of digital technologies on learning outcomes. This complicates the process of making informed decisions on the further development of digitalisation in education.

Therefore, the main problematic area of the study is to find an optimal balance between innovative digital approaches and traditional values of education, as well as to develop a comprehensive strategy that takes into account the technological, pedagogical, psychological and organisational aspects of digital transformation. Solving these problems will help create an effective model of digital education that can meet the requirements of the present and provide quality training for future professionals.

2. Analysis of recent research and publications. Recent research on the digital transformation of education highlights both its transformative potential and the multifaceted challenges it presents. Scholars such as McCarthy et al. (2023) emphasize that successful digital transformation requires systemic changes in organizational culture and leadership, rather than mere technological adoption. Their framework identifies four critical components: leadership, people, technology, and experience, underscoring the need for holistic strategies that align with the specific needs of educational environments. Similarly, Dushchenko (2021) argues that digitalization in Ukraine must go beyond technical upgrades to encompass a paradigm shift in educational approaches, preparing students and teachers for the demands of a digital society. These studies collectively stress the importance of integrating digital tools with pedagogical and psychological support to ensure meaningful and sustainable change.

The challenges of digitalization are further explored in works by Verbowskyi (2024) and Petryshyn et al. (2023), who highlight issues such as the digital divide, insufficient infrastructure, and the psychological readiness of educators and students. Verbowskyi points to disparities between urban and rural schools, while Petryshyn et al. focus on the psychological aspects, noting that motivation, adaptability, and emotional resilience are crucial for effective digital integration. The COVID-19 pandemic and the war in Ukraine have accelerated the need for digital solutions, as noted by Martynenko (2023), who discusses the role of platforms like Zoom and Google Meet in maintaining educational continuity. However, these rapid changes have also exposed gaps in digital literacy and resource availability, calling for targeted investments and policy support.

Comparative studies, such as those by Virotchenko (2024) and Stoika (2021), provide valuable insights into international approaches to digitalization. Virotchenko contrasts Ukrainian and Baltic strategies, noting the latter's focus on individualized learning and alignment with European standards. Stoika examines

teacher training in Poland, Hungary, and Ukraine, advocating for the adoption of best practices from more advanced systems. These studies suggest that while Ukraine has made progress in digital education, further collaboration with international partners and adaptation of global frameworks could enhance its effectiveness. Overall, the literature underscores the need for balanced, context-sensitive strategies that address technological, pedagogical, and human factors to realize the full potential of digital transformation in education.

3. The purpose of the article. The purpose of this article is to examine the challenges and opportunities of digital transformation in Ukraine's education system, focusing on issues such as the digital divide, teacher preparedness, and maintaining educational quality. It aims to analyze international best practices and propose strategies for developing a balanced, effective approach to digitalization in education. Ultimately, the article seeks to contribute to the creation of a sustainable digital education model that combines innovation with traditional pedagogical values.

4. Presenting main material. A. McCarthy, D. Maor, A. McConney, & C. Cavanaugh emphasise that true digital transformation in education requires changes in attitudes and organisational culture, not just the introduction of the latest technologies. Based on a thorough analysis of 20 international digital transformation frameworks from different sectors, the researchers identified four interrelated key components that are crucial for the successful transformation of education systems. The first and most important component is leadership, which includes developing a clear strategy, building a culture of trust among all stakeholders in the educational process, and communicating changes effectively. The second component, people, emphasises the need for comprehensive support for teachers, development of their professional skills and adaptation to new conditions. The third pillar relates to technology, in particular its role in personalising learning and ensuring data security. The fourth component, experience, is focused on creating an educational environment that takes into account the needs of students to the fullest extent possible. The researchers also emphasise the importance of developing teachers' professional skills, using data to personalise learning, and creating secure digital ecosystems. They give examples of highly effective education systems, such as Finland and Singapore, which have already implemented transformational changes (McCarthy et al.,2023).

The main conclusion of the study is that without fundamental changes in thinking and approaches to the organisation of the educational process, no technological innovations, even the most advanced ones, will have the desired effect. Scholars emphasise that the transformation process should not begin with the mechanical introduction of new technological solutions, but with the development of a holistic strategy that takes into account the specifics of the educational environment and the needs of all its participants (McCarthy et al., 2023). Therefore, we propose a framework for digital transformation in education aimed at overcoming barriers, improving the quality of learning and preparing students for future challenges in the digital world.

O. Dushchenko examines in detail the process of digital transformation of the educational sector in Ukraine, focusing on its necessity in the face of modern challenges. The scientist notes that the digitalisation of education is not just a fashion trend, but an objective requirement of the times, driven by global informatisation processes, technological development and the consequences of the COVID-19 pandemic.

The researcher believes that the transition to a digital learning format involves not only technical upgrades, but also a radical change in the educational paradigm. It is emphasised that modern education should prepare specialists who are able to work effectively with information, use the latest technologies and adapt to rapid changes. Particular attention is paid to the development of future teachers' digital competence, which includes not only the ability to use technical means, but also the ability to integrate them into the learning process to achieve better results (Dushchenko, 2021).

According to O. Dushchenko, the key aspects of digitalisation are the creation of a modern digital educational environment, the development of high-quality e-content, and the updating of the regulatory framework. The scientist gives examples of successful tools, such as interactive platforms (Padlet, Mindomo, PearDeck), which can already significantly improve learning efficiency. However, it is emphasised that in order to fully realise these opportunities, a number of obstacles need to be overcome, including the insufficient level of digital literacy of teachers, lack of technical support, and the need to further improve the legislative framework (Dushchenko, 2021).

Thus, the digitalisation of education is an inevitable need of our time that requires a comprehensive approach. Its successful implementation depends on a harmonious combination of state support, the activity of the teaching community, and the continuous improvement of technological solutions. Only under such conditions can digitalisation become a real catalyst for qualitative changes in the education system, helping to prepare competitive specialists for the future.

C.Virotchenko notes that the digitalisation of education is a key tool for creating an innovative learning environment that increases the competitiveness of educational systems and promotes the individual development of participants in the educational process. The scientist believes that this process covers a wide range of technological, pedagogical and socio-cultural aspects, including the use of digital platforms, interactive teaching methods and the development of digital competence. In particular, in Ukraine, the digitalisation of education has become particularly relevant due to the COVID-19 pandemic and the armed conflict, which has stimulated the development of distance learning and digital educational resources. It is noteworthy that digitalisation not only improves the quality of education, but also ensures flexibility, accessibility and adaptation to the needs of modern society. In the Baltic States, digitalisation is seen as a tool for creating individualised learning, increasing student motivation and meeting European standards. Baltic researchers focus on practical aspects, such as the use of digital tools for assessment and the development of skills needed for the labour market (Virotchenko, 2024).

Thus, the digitalisation of education in Ukraine and the Baltic States is a strategic direction aimed at modernising the educational space, improving its quality and competitiveness. Despite the differences in approaches, both regions consider digital technologies as a means to achieve stability, innovation and openness of education in the face of global challenges.

The digitalisation of teacher training is a key element of the current educational transformation that is taking place in Poland, Hungary and Ukraine. This process requires a thorough analysis, taking into account the different socio-cultural, technological and regulatory conditions of each country. O. Stoyka emphasises that the digitalisation of education promotes innovative forms of education, such as virtual and network

universities, and improves the quality of teacher training adapted to the requirements of the modern digital world. The researcher notes that Ukraine, despite the challenges posed by the COVID-19 pandemic and other crises, is actively introducing digital technologies into education, but needs to learn from the experience of European countries, such as Poland and Hungary, which have made significant progress in this area. They also emphasise the need to develop the digital competence of teachers, as research shows that most Ukrainians have insufficient digital skills (Stoyka, 2021).

Therefore, the digitalisation of teacher training is an integral part of the modernisation of education in the context of globalisation and technological progress. For Ukraine, it is important to study and adapt European experience, especially that of Poland and Hungary, to ensure the competitiveness of the national education system. This will create effective mechanisms for training teachers who can use modern digital tools to improve the quality of education.

Ukrainian scientists summarise the results of research by the Institute of Digitalisation of Education of the National Academy of Sciences of Ukraine on the introduction of innovative technologies in the educational process. Particular attention is paid to cloud services such as Google Workspace for Education, virtual and augmented reality technologies, and gamification. The research covers the development of teachers' digital competence, in particular through self-assessment tools, and analyses the actual practice of using ICT in teachers' professional activities based on large-scale surveys. A separate section is devoted to the use of virtual reality in the training of specialists. The collection also discusses the Ukrainian Electronic Encyclopedia of Education project aimed at systematising pedagogical knowledge and innovative approaches to gamification, especially in teaching IT students. All materials emphasise the importance of adapting educational technologies to the needs of students and teachers. The publication contains up-to-date data from 2021-2023, reflecting the challenges of distance and blended learning in Ukraine (Pinchuk, 2023).

Thus, the researchers conclude that digitalisation of education is a powerful tool for transforming the educational process that requires systematic implementation. They prove that the use of cloud technologies, virtual and augmented reality significantly increases learning efficiency and student motivation. An important aspect is the need to develop teachers' digital competence, which is confirmed by the results of large-scale studies. The researchers emphasise that the successful integration of digital tools into education requires not only technical support but also methodological support and adaptation to the needs of specific educational institutions. The researchers see particular promise in the development of gamified learning environments and interactive platforms that promote active learning. At the same time, they note that the digitalisation process should be gradual and take into account the real conditions of the Ukrainian education system.

Digital transformation in education covers a wide range of concepts, such as virtual reality, cloud computing, and other technologies that change traditional teaching methods. According to Trinh Thi Phuong et al.(2023), this process opens up new opportunities for online learning, blended learning, and data analytics to help make informed decisions in education. The authors emphasise that research in this area remains fragmented, despite the rapid growth of publications in recent years, especially during the COVID-19 pandemic.

According to the researchers, digital transformation in education is developing in four main areas: the impact of the pandemic on higher education, the integration of the technologies of the Fourth Industrial Revolution, the development of digital competence, and the use of innovative forms of learning, such as e-learning and blended learning. They also note that researchers from countries such as Indonesia and Thailand demonstrate high citation performance. The researchers analyse the digital transformation in education through a bibliometric approach, identifying four key areas: the impact of COVID-19, Industry 4.0 technologies, digital competence, and innovative forms of learning. They note the rapid growth of research in recent years, especially in developed countries, but also note the activity of researchers from developing countries. However, a significant number of publications remain little known due to low citation rates (Trinh Thi et al.,2023). Thus, digital transformation in education is a dynamic area that requires further study, international cooperation and integration of modern technologies for the effective development of educational systems.

C.Martynenko notes that the digitalisation of the educational process in higher education institutions is an integral part of modern transformations that contribute to the renewal of content and technological support for learning and improve its quality. The scientist believes that digital technologies play a key role in creating a flexible, personalised and accessible educational space, especially in the context of martial law and global challenges such as the COVID-19 pandemic. The scientist notes that digitalisation is not only the technical introduction of new tools, but also the deep convergence of digital technologies with pedagogical and social practices. Among the main conditions for successful digitalisation, she identifies: the presence of a digital generation of students with specific socio-psychological characteristics; a developed legislative framework; resource support (digital platforms, Internet access); training of teachers with digital competencies (Martynenko, 2023).

According to S. Martynenko, digital technologies such as Zoom, Google Meet, Canva, and Genially significantly expand the possibilities of the educational process, making it interactive, mobile, and adaptive. However, she also draws attention to the challenges faced by educational institutions: insufficient digital literacy, outdated technical facilities, lack of quality content, and bureaucracy. The researcher emphasises that the digitalisation of education is a complex but necessary process that requires a systematic approach, investment in infrastructure and training. Therefore, successful transformation of the educational space is only possible if the needs of all participants in the process are taken into account, modern technologies are integrated with traditional teaching methods, and digital competencies are continuously developed. This will allow higher education institutions not only to meet modern challenges, but also to form future professionals ready to work in the digital economy (Boychuk et al.,2024).

L. Petryshyn, O. Pochuieva, M. Lemeshchuk, and V. Zvozdetska note that the digital transformation of education today is not only a technological challenge, but also a complex psychological and pedagogical phenomenon. The authors believe that the success of this process depends primarily on the psychological readiness of all participants in the educational process to change. The researchers emphasise five key psychological aspects that determine the effectiveness of digitalisation: motivational (awareness of the need for digital competences), self-organisational (active learning of new skills), adaptive (ability to change),

stabilising (finding a balance between traditional and innovative methods) and regulatory (prevention of digital stress) (Petryshyn et al.,2023).

According to L. Petryshyn and her colleagues, the COVID-19 pandemic has become a powerful catalyst for digital transformation, while revealing both the advantages of new learning formats (flexibility, accessibility) and their weaknesses (psychological stress, technical limitations). The authors emphasise that digital tools alone do not guarantee quality education – the key role is played by the psychological readiness of teachers and students to use them

Thus, researchers argue that the digital transformation of education requires an integrated approach that combines technological innovations with psychological and pedagogical support. They suggest developing a synergistic model that integrates digital competencies with the development of emotional intelligence and social skills. They also emphasise that without taking into account psychological factors, any technological changes in education risk remaining superficial and ineffective.

P.Prima, O. Goncharuk, D. Prima, and R. Roslavets offer a multifaceted analysis of the digitalisation process in education, which combines theoretical generalisations with practically oriented conclusions. The originality of the study lies primarily in its thorough adaptation of global trends to the Ukrainian educational context. The researchers not only state general trends, but also carefully analyse the legal framework of Ukraine and the orders of the Ministry of Education and Science, which allows them to clearly define the place of national education in the European space. An important scientific contribution is the conceptual understanding of digitalisation not just as a technical upgrade, but as the formation of a new 'cyber-physical space' where virtual and real educational processes are closely intertwined. Scientists emphasise that digital technologies create a fundamentally new environment for education, which requires a rethinking of traditional approaches to learning. In this context, special attention is paid to the analysis of such innovative areas as artificial intelligence, robotics, virtualisation of learning and the development of digital competence of all participants in the educational process (Prima et al.,2023).

The practical value of the study lies in the clear definition of strategic tasks for Ukrainian education, including the integration of digital technologies into curricula, infrastructure modernisation, and professional development of teaching staff. Therefore, it is important that R. Prima, O. Honcharuk, D. Prima, and R. Roslavets do not idealise the process of digitalisation, but point to its contradictions, in particular, the risks of losing the humanistic component of education and the need for a balanced approach to innovation.

I. Verbovskyi thoroughly explores the transformational potential of digital technologies in modern education. He notes that digitalisation has become an integral part of the educational process, especially in the face of global challenges such as the COVID-19 pandemic and the full-scale war in Ukraine. The scientist believes that digital tools are fundamentally changing traditional approaches to learning, making education more accessible, flexible and personalised. Particular attention is paid to the analysis of such innovative areas as cloud technologies, virtual reality, massive open online courses (MOOCs), which open up new opportunities for learning. According to the scientist, these technologies not only change the form

of education but also affect its content, contributing to the development of critical thinking and digital literacy (Verbowskyi, 2024).

The originality of this study lies in a comprehensive approach to analyzing the digitalization of education in times of crisis. The researcher not only states the benefits of digital technologies, but also identifies significant challenges faced by Ukrainian education. Among them are the digital divide between urban and rural schools, insufficient technical equipment of institutions, and the need to improve the skills of teachers. An important scientific contribution is the development of practical recommendations for the implementation of digital technologies in the educational process. Specific steps are proposed, in particular: development of digital learning infrastructure; creation of a national educational platform; introduction of blended learning formats; development of digital competencies among teachers and students. Particular attention should be paid to the analysis of the impact of digitalization on the changing role of the teacher. The author emphasizes that in the context of digital transformation, a teacher turns from a knowledge carrier into a moderator of the educational process, which requires fundamentally new approaches to teacher training (Verbowskyi, 2024).

Thus, the digitalization of education is an objective process that opens up new prospects for the development of the educational system. However, to realize its potential, a number of challenges need to be overcome, including ensuring equal access to digital technologies, developing effective mechanisms for assessing the quality of digital education, and preserving the humanitarian component of the educational process.

5. Conclusions. Current research on digital transformation in education shows that a successful transition to new forms of education requires a comprehensive systematic approach that goes far beyond simple technical upgrades. Based on the analysis of international experience and research, a number of important conclusions can be drawn.

First of all, the digital transformation of education involves a holistic rethinking of all aspects of the learning process. Studies clearly show that individual technological innovations without parallel changes in pedagogical approaches, organizational culture, and teacher training do not have the expected effect. Particular attention is needed to develop clear strategies that take into account both national peculiarities and the specifics of individual educational institutions.

The analysis reveals several key challenges faced by education systems. Technical barriers include unequal access to the Internet and digital devices in different regions, which creates the so-called “digital divide.” Human resources problems are manifested in the insufficient level of digital competence among teaching staff, while methodological difficulties are related to the lack of unified tools for assessing the quality of digital learning. Psychological factors, such as natural resistance to change among participants in the educational process, are also worth noting.

The experience of leading countries in digital education, such as Finland and Singapore, shows that successful digitalization never means a complete abandonment of traditional methods. The most effective models of education of the future are based on a harmonious combination of innovative digital tools (virtual

laboratories, gamified platforms, artificial intelligence for personalized learning) with classical forms of learning, such as live discussions and group projects. Of particular importance is the development of the so-called "soft" skills, such as critical thinking, creativity, and emotional intelligence, which remain relevant regardless of technological progress.

Based on the analysis of scientific works, we can identify clear stages of successful digital transformation of educational institutions. The preparatory stage includes a thorough assessment of the existing infrastructure and comprehensive training of the teaching staff. The adaptation period involves the gradual implementation of pilot projects with further analysis of their effectiveness. The full integration stage involves the large-scale implementation of digital solutions in all areas of the educational process. The optimization phase involves continuous monitoring of results and process adjustments based on the data obtained.

Promising areas for further research include studying the impact of artificial intelligence on the personalization of learning, developing unified standards for digital pedagogy, analyzing the long-term impact of digitalization on the quality of education, and improving blended learning models. Studies of the psychological aspects of digital education, in particular the impact of technology on students' motivation and socialization, are of particular relevance.

Thus, the digital transformation of education is a complex, multi-level process that requires concerted action by all participants, from government agencies to individual teachers. The most effective results are achieved when technological innovations are combined with a deep understanding of pedagogical principles and psychological characteristics of the learning process. The future of education lies not in full digitalization, but in the intelligent integration of technologies that complement and expand, but do not replace, traditional values and methods of education. Successful implementation of digital transformation will create a flexible, adaptive education system capable of preparing specialists for the challenges of the rapidly changing digital world, while maintaining the fundamental principles of quality education.

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