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ANALYSIS OF ASPECTS OF THE DIGITAL TRANSFORMATION OF THE EDUCATION SYSTEM IN RUSSIA

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Abstract. The article presents a comprehensive analysis of the digital transformation of the education system, which is understood as a fundamental shift in the pedagogical paradigm driven by modern technologies. The authors highlight key aspects of digitalization, including technical equipment, the development of digital resources, the formation of a digital culture, and the legal framework. Special attention is given to the benefits of digital technologies, such as personalized learning, increased visibility of teaching materials, and the development of critical thinking in students.

The main problems of digital transformation are considered: regional differences in access to technology, inadequate training of teaching staff, and the need to methodologically justify the effectiveness of digital tools. The authors emphasize the importance of a balance between technological innovation and pedagogical appropriateness, as well as the need for interdisciplinary research to assess the long-term impact of digitalization on the quality of education.

Promising areas of development include the creation of adaptive educational environments, the introduction of virtual and augmented reality technologies, and the transparency of educational processes. The article will be of interest to researchers, teachers, and education managers dealing with digital transformation issues.

Keywords: *digital transformation, education, digitalization, personalization of learning, digital technologies, pedagogical innovation, regional inequality, methodological justification, adaptive systems, information transparency*

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The modern education system is undergoing a phase of fundamental change, driven by the rapid development of digital technologies and their increasing penetration into all areas of human activity. The process of digitalization of education is now considered not only as a technical modernization of the educational process, but as a comprehensive transformation of the entire educational paradigm, affecting the methodological, content, and organizational aspects of education.

Several key factors determine the relevance of examining the digitalization of education. First, modern digital technologies create

fundamentally new opportunities to improve the quality and accessibility of education. Second, they enable students to develop skills that meet the challenges of the digital economy and the demands of the 21st-century labor market. Thirdly, the digital transformation of education is becoming an essential element of national development strategies in many countries, including Russia and Kazakhstan.

It is worth noting that the term “digitalization of education” is interpreted ambiguously in modern scientific literature. In the broadest sense, it includes: the technical equipment of educational institutions, the development and implementation of digital educational resources, the formation of a digital culture among participants in the educational process, the creation of a legal framework for digital education, and the development of infrastructure for distance learning and blended learning.

At the same time, the researchers note that the digitalization of education entails not only the use of new technological tools but also a fundamental shift in approaches to organizing the educational process, teaching methods, and the assessment of results.

However, despite the apparent potential of digital transformation, this process faces several significant challenges. These include: insufficient development of the methodological foundations of digitalization, problems in training teachers to work in the new conditions, digital inequality between regions and social groups, the need to revise educational content, psychological and pedagogical aspects of adapting students to the digital environment, issues of information security, and digital ethics.

The problem of methodological justification of digitalization deserves special attention. As experts rightly emphasize, the introduction of digital technologies into the education system should be based on a serious scientific foundation and not be pursued as an end in itself. This requires complex interdisciplinary research that combines the achievements of pedagogy, psychology, computer science, and other sciences.

A distinctive feature of the research is its comprehensive approach to analyzing the digitalization of education, which considers not only technological aspects but also pedagogical, psychological, social, and economic factors. The authors aim to avoid both a technocratic approach that overemphasizes the role of digital tools and a conservative skepticism that underestimates the potential of digital transformation.

One of the most pressing and controversial issues in the modern digital transformation of education is the problem of scientifically and methodologically substantiating the effectiveness of digital technologies

in the educational process. As E. Kiseleva and V. Tsarkova rightly note, the methodology should provide a sufficient and convincing (scientifically verified and practically implementable) rationale for the digitalization of education [1, p. 106]. This statement highlights the core issue of the current stage of technological modernization in the education system: the need to transition from the spontaneous introduction of digital tools to their systematic, scientifically justified use, with a clear understanding of the pedagogical implications and potential risks.

Today, there is no uniform, generally accepted evidence base in Russian and international educational practice that comprehensively assesses the effectiveness of digitalization based on various parameters, including its impact on the quality of knowledge acquisition, the development of professional competencies, student motivation, the accessibility of education, and other key indicators. The lack of such a methodological justification leads to several serious problems. These include the unsystematic use of technologies, the lack of clear criteria for evaluating their effectiveness, and, consequently, the inability to objectively determine the actual impact of digital tools on educational outcomes.

However, despite the lack of a comprehensive evidence base, individual studies and practical experience show a range of convincing evidence of the positive impact of digitalization on the modernization of education. In particular, numerous studies confirm that the correct use of digital technologies:

1. Promotes the development of individualized educational pathways through adaptive learning systems that take into account the cognitive characteristics and learning pace of each student.

2. Increases the visibility and accessibility of complex educational material through the use of multimedia resources, virtual and augmented reality technologies, especially in fields such as science, medicine, and engineering.

3. Expands students' opportunities for independent work through access to digital educational resources anytime, anywhere.

4. Creates the conditions for the development of critical thinking and information literacy as key 21st-century skills.

5. Improves feedback in the teacher-student system through automated systems for assessing and analyzing educational outcomes.

The question of the need for a differentiated approach to methodological justification of digitalization for various levels of

education (schools, universities, and further education institutions), different subject areas, and forms of education warrants special attention. For example, the effectiveness of using digital technologies in teaching the exact sciences may differ significantly from their impact on the humanities, which requires the development of specific methodological approaches.

An essential aspect of the scientific underpinning of digitalization is the analysis not only of its benefits but also of the potential risks, which include digital inequality, a decline in face-to-face professional communication, a possible deterioration of cognitive functioning due to excessive reliance on digital tools, and other adverse effects. A comprehensive assessment of the balance between benefits and risks should form the basis for developing balanced models for the digitalization of education in general.

A promising direction for the digital transformation of education is to conduct longitudinal studies to assess the long-term impact of digital technologies on the quality of education, and to create experimental platforms to test and evaluate the effectiveness of different digital pedagogical tools. Of particular value are comparative studies that analyze the experiences of other countries and education systems in the field of digitalization.

Digital technologies are changing education in three ways:

- formal processes – organizational changes such as the introduction of electronic journals and learning management systems;
- content aspect – updating methods of knowledge transfer, including the use of multimedia resources;
- mental concept – development of digital skills and adaptation of students to new learning conditions [2, p. 9].

These changes require not only technical equipment but also a revision of pedagogical approaches, which underscores the duality of digitalization: on the one hand, it formalizes routine processes, and on the other hand, it creates conditions for creativity and self-directed learning [3, p. 45].

One of the most acute and systemic problems of the digital transformation of education in Russia is the pronounced regional asymmetry in terms of the pace and quality of digital technology implementation. As Li Yajuan convincingly demonstrates in his study, the current educational situation varies significantly across different regions due to differences in economic development or geographical location [4, p. 209]. This is confirmed by data from monitoring studies,

which reveal a significant gap between capital regions, large cities, and rural areas in key indicators, including the technical equipment of educational institutions, access to high-speed internet, and the availability of modern digital educational resources. This problem is particularly acute in the remote areas of Siberia, the Far East, and the North Caucasus, where geographical remoteness is compounded by underdeveloped infrastructure and a shortage of qualified personnel.

The depth of the digital divide between the regions becomes even clearer when analyzing parameters such as the number of computers per student, the speed of internet connection in educational institutions, and the availability of specialized software. For example, if in Moscow schools on average there are 5–7 students per computer, in some rural schools this number can reach 20–25 students. The quality of the Internet connection also remains a significant issue – in many rural schools, the speed is limited to 1–2 Mbps, which makes it impossible to utilize modern cloud-based learning platforms and video lessons. This situation creates the conditions for the formation of a ‘digital barrier’ between students from different regions, which in the long term can lead to increased social inequality and limited social mobility for young people from remote areas.

In mid-May 2024, the government of the Russian Federation published the annual report on the implementation of state education policy in 2023, which states: The proportion of schools with high-speed internet (over 50 Mbit/s): Moscow and St. Petersburg – 98%; the Republic of Dagestan – 34%; Zabaykalsky Krai – 28%.

An equally significant problem that directly affects the effectiveness of digital education transformation is the level of professional training among teaching staff. According to research data, “the general educational qualifications of primary school teachers are low, and their information literacy is incomplete” [4, p. 210]. This problem is multifaceted: on the one hand, many teachers, especially those from the older generation, struggle to master the new digital technologies; on the other hand, even young professionals often lack the necessary skills to integrate digital tools into the classroom in a methodologically competent manner. This problem is particularly acute in rural schools, where there is a double deficit: a lack of both technical equipment and qualified teachers who can work effectively with the available digital resources [5].

The conducted analysis allows us to identify several key factors that exacerbate the problem of digital inequality between regions: different budget financing of educational institutions in various subjects of the

Russian Federation, uneven development of telecommunications infrastructure, migration of qualified teaching staff to more developed regions, lack of uniform standards for digital equipment of educational institutions, lack of targeted programs for training and retraining of teachers to work in the digital environment.

Additionally, digitalization necessitates a revision of educational content. As A. Kisarin emphasizes, education should include the acquisition of skills that employers need [6, p. 160]. This leads to a shift in emphasis from traditional disciplines to practice-oriented modules, which in turn sparks discussions about the balance between basic and applied knowledge.

The modern digital transformation of education presents fundamentally new opportunities for implementing the concept of personalized learning, which considers the individual characteristics, abilities, and educational needs of each student. As researchers note, digitalization opens up unprecedented prospects for creating adaptive educational environments, in which the educational process can be designed as individually as possible [7, p. 305]. This is made possible by the extensive use of modern digital tools and pedagogical methods that allow us to design unique educational paths for each student [5].

A key element of personalized learning in the digital age is the use of blended education formats that optimally combine the advantages of traditional classroom learning with the possibilities of digital technologies. Such hybrid models allow students to set their own pace of learning, choose the most suitable formats for interacting with educational content and teachers, and organize their learning time flexibly. Flipped classroom models are particularly effective, where theoretical material is studied independently using digital resources, and class time is dedicated to practical application of knowledge and in-depth discussion of complex topics.

It is essential to emphasize that the effective personalization of learning in a digital environment necessitates not only technological solutions but also the development of a digital culture among all stakeholders involved in the educational process [8, p. 138]. The formation of a digital culture should become an integral part of both individual disciplines and comprehensive general education programs. This includes developing a whole range of competencies in students: from basic skills in using digital tools to the ability to critically evaluate information, build a digital identity, and adhere to ethical standards in a virtual environment.

Introducing elements of digital culture into the educational process requires a systematic approach. This includes: developing specific digital literacy modules within different disciplines, creating conditions for the practical application of digital skills in academic and research activities, creating a digital portfolio of students that reflects their achievements and competencies, and organizing events to develop digital culture [9].

Preparing teachers to work in the context of personalized digital learning is particularly important. Teachers must not only master modern technologies, but also understand the methodology of how to use them to support students individually. This requires a revision of approaches to improve teachers' qualifications, with a focus on mastering tutoring support methods, adaptive learning technologies, and educational data analysis tools.

The personalization of learning through digital technologies poses new challenges to assessment systems in education. Traditional methods of knowledge assessment are insufficient for accurately evaluating students' progress in a digital environment. This requires the development of new formative assessment systems that analyze students' digital footprints and utilize artificial intelligence technologies to identify individual educational needs.

To fully leverage the potential of digital personalization in learning, a comprehensive approach that combines technological infrastructure, methodological support, and organizational changes within the educational process is necessary. Only such a systematic approach will create a truly flexible and adaptable educational environment capable of meeting the diverse academic needs of students within the context of society's digital transformation. At the same time, it is crucial to maintain a balance between technological possibilities and pedagogical feasibility so that digital tools serve the goals of personal development, and do not become an end in themselves of the educational process.

Ensuring the quality of modern education in the context of digital transformation requires fundamentally new approaches to organizing the educational process, in which the principle of transparency for all key educational processes is of particular importance. As N. Tarkhanova rightly notes, "the use of digital technologies leads to greater openness of information, which is an important aspect of quality assurance" [10, p. 133]. This idea is confirmed in the practice of leading educational organizations, where digital openness is not just an additional tool but a fundamental principle of organizing educational activities.

At the same time, digital technologies enable the organization of this process while maintaining the necessary balance between openness and the protection of personal data, which is particularly important in the context of current legislation on information protection.

Modern education management systems, based on the principles of digital transparency, also include open data on the material and technical base of educational organizations, as well as the results of monitoring the quality of education, employment rates, and the number of graduates, among other vital aspects of academic activities. Such a comprehensive approach to information openness enables the creation of a system of multilateral feedback, in which not only educational organizations provide information about their activities, but all interested parties have the opportunity to participate in the discussion and improvement of the educational process. Sociological research conducted at our university has shown that teachers who utilize AI algorithms to individualize tasks have seen a 22% increase in their students' academic performance. The introduction of the SmartTrack system into the educational process organization has reduced the time teachers spend reviewing their students' work by 35%.

Digital document management and education management systems play a special role in ensuring the transparency of education processes. They enable the tracking of all key stages of the education process in real-time – from the submission of an application for admission to the issuance of the diploma. This not only increases the efficiency of administrative processes but also significantly reduces the risk of corruption, creating the conditions for an honest and objective educational environment.

It is essential to note that the digital transparency of education extends beyond the formal aspects of the educational process organization. Modern technologies enable the substantive elements of education to become more open, including teaching methods, approaches to organizing students' independent work, and forms of interaction between participants in the educational process. Such transparency of content helps to create a new quality of the academic environment, based on the principles of cooperation, mutual learning, and continuous improvement.

The experience of leading educational organizations shows that the consistent implementation of the principles of digital transparency leads to a significant improvement in the quality of education due to several interrelated factors: firstly, by creating a system of public control over

the quality of educational services, secondly, by forming a culture of continuous improvement at all levels of the educational system, and thirdly, by increasing the motivation of all those involved in the educational process to achieve high results. At the same time, digital transparency is not an end in itself, but rather the most critical tool for ensuring the quality of education, as well as the opportunity to contribute to its continuous development and adaptation to the changing demands of modern society. Particular attention is paid to the development of “21st century skills” such as critical thinking, collaboration, and information literacy [11, p. 123]. These skills form the foundation for graduates to adapt to the conditions of the digital economy successfully.

The digitalization of education is a complex and multi-layered process that requires an integrated approach at all levels of the education system, from pre-school to higher vocational education. This process not only affects the technical equipment of educational institutions but also requires a radical overhaul of the methodological foundations of pedagogical action, the content of educational programs, and approaches to assessing learning outcomes. Many teachers, especially those from the older generation, struggle to deal with new technologies and often fail to recognize their educational potential. This problem is exacerbated by the lack of a systematic program to improve teachers’ digital skills and insufficient methodological support for digitalization processes at the local level. Despite the existing difficulties, however, digital technologies open up fundamentally new opportunities for modernizing the entire education system. They allow us to overcome geographical barriers, make education more accessible and individualized, and significantly expand the range of pedagogical technologies used.

Among the key areas of digital education development, several priority areas can be identified. The first and most important area is the creation of a standardized methodological basis for digital education. This includes the development of scientifically sound standards for the use of digital technologies in education, the creation of uniform platforms for publishing educational content, and the development of criteria for evaluating the effectiveness of digital educational technologies. Without such a basis, the digitalization process runs the risk of becoming a chaotic implementation of technologies without adequate pedagogical justification.

The second most important area is the improvement of teachers’ qualifications in utilizing digital technologies. This requires the creation of a system of continuous professional development for teachers that

includes both the acquisition of technical skills in using digital tools and an understanding of the methodology for their application in the educational process. Particular attention should be paid to the training of tutors who will be able to provide methodological support to their colleagues in this area.

The third strategic direction involves individualizing educational paths with the aid of digital technologies. Modern educational platforms and adaptive learning systems enable the consideration of individual student characteristics, learning pace, and cognitive preferences. This opens up new possibilities for implementing the principles of personalized learning, which are particularly important in the context of inclusive education.

The fourth key area is ensuring transparency and accessibility of education through digital technologies. The development of open educational resources, the creation of digital portfolio systems, and the introduction of blockchain technologies to record educational achievements can make the educational process more transparent and accessible to all its participants.

The implementation of these areas requires a coordinated approach from all stakeholders, including government agencies, individual teachers, and educational technology developers. It is necessary to develop a comprehensive program for the digital transformation of education, which includes not only a technological component but also serious methodological training, changes in the legal framework, and the creation of a motivation system for all those involved in the educational process. Only with such a systematic approach will it be possible to fully realize the potential of digital technologies in creating a modern, flexible, and effective education system that can meet the challenges of the 21st century.

Promising areas for further research in the field of digital education should focus on addressing several fundamental problems that are crucial for a successful transformation of the education system. Of particular importance is the search for an optimal balance between the formal and informal aspects of digital learning, which requires in-depth interdisciplinary research involving specialists from the fields of pedagogy, psychology, sociology, and digital technologies. The formal aspects of digitalization, including legal regulation, standardization of educational programs, and a system of formal assessment of learning outcomes, must be harmoniously combined with informal elements, such as the development of a digital culture of participants in the educational

process, the formation of professional networking communities, and support for informal educational initiatives. At the same time, special attention should be paid to studying the psychological and pedagogical effects of digitalization, the transformation of communication models in the digital educational environment, and the impact of digital technologies on learning motivation.

An equally important area of scientific research should be the development of differentiated strategies for digitalizing education that take into account the specificities of different regions. Such strategies should be based on a comprehensive analysis of regional characteristics, including the level of technological development, the state of educational infrastructure, human resources, and socio-cultural factors. Research on bridging the digital divide between urban and rural areas, as well as between different federal subjects, deserves special attention. In this regard, it seems promising to study models of network interaction between educational organizations, develop adaptive programs to improve the digital literacy of teachers, taking into account regional specifics, and analyze the effectiveness of various mechanisms of state support for digitalization in problem regions.

Let us make it clear that the most important task of future research is also the development of methodological foundations for evaluating the effectiveness of the digital transformation of education. To this end, a comprehensive system of indicators must be created that enables the assessment not only of the technical equipment of educational institutions but also of the actual impact of digital technologies on the quality of educational outcomes, the availability of education, and the development of key student skills. Of particular importance are longitudinal studies that enable the tracking of the long-term effects of digitalization at various levels of the education system.

It should be noted that a separate area of research should be devoted to studying the best practices of digitalizing education, both in Russia and abroad, with subsequent adaptation of the most successful solutions to Russian conditions. This includes a comparative analysis of various models of digital education transformation, identification of success factors, and obstacles to implementation. Particular attention should be paid to studying the experience of digitalization in countries with similar socio-economic conditions and comparable territorial dimensions.

Research into the possibilities of integrating the latest technological developments (such as artificial intelligence, virtual and augmented reality, blockchain) into the educational process, with a mandatory

assessment of their pedagogical effectiveness and possible risks, also appears promising. This also includes research in the field of protecting the personal data of participants in the educational process, preventing digital dangers and threats, and developing methods for forming a digital culture and responsible behavior in the digital environment among all participants in the educational process.

The implementation of the above-mentioned research areas, therefore, requires the consolidation of the efforts of the scientific community, educational organizations, educational authorities, and representatives of the IT industry. The creation of a distributed network of research centers specializing in various aspects of digital education and fostering a continuous dialogue between researchers and practitioners is of great importance. This will not only deepen the theoretical understanding of the digital transformation processes in education but also provide a scientific basis for informed management decisions, thereby contributing to the sustainable development of the digital education environment in Russia.

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АНАЛИЗ АСПЕКТОВ ЦИФРОВОЙ ТРАНСФОРМАЦИИ ОБРАЗОВАТЕЛЬНОЙ СИСТЕМЫ РОССИИ

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Аннотация. Статья посвящена комплексному анализу цифровой трансформации системы образования, которая рассматривается как кардинальное изменение педагогической парадигмы под влиянием современных технологий. Авторы выделяют ключевые аспекты цифровизации, включая техническое оснащение, развитие цифровых ресурсов, формирование цифровой культуры и нормативно-правовой базы. Особое внимание уделяется преимуществам цифровых технологий, таким как персонализация обучения, повышение наглядности учебного материала и развитие критического мышления у учащихся.

Рассматриваются основные проблемы цифровой трансформации: региональные различия в доступе к технологиям, недостаточная подготовка педагогических кадров и необходимость методологического обоснования эффективности цифровых инструментов. Авторы подчеркивают важность баланса между технологическими инновациями и педагогической целесообразностью, а также необходимость междисциплинарных исследований для оценки долгосрочного влияния цифровизации на качество образования.

Перспективными направлениями развития являются создание адаптивных образовательных сред, внедрение технологий виртуальной и дополненной реальности, а также прозрачность образовательных процессов. Статья представляет интерес для исследователей, педагогов и менеджеров образования, занимающихся вопросами цифровой трансформации.

Ключевые слова: цифровая трансформация, образование, цифровизация, персонализация обучения, цифровые технологии, педагогические инновации, региональное неравенство, методологическое обоснование, адаптивные системы, информационная прозрачность

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