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DIGITAL TRANSFORMATION FOR SUSTAINABLE DEVELOPMENT OF HIGHER EDUCATION

Abstract: Digital transformation in higher education represents a comprehensive strategic process that transcends technological modernization and embraces institutional, managerial, and pedagogical innovations. This paper explores the evolution of digital transformation in Kazakhstan – from informatization and digitalization to a fully integrated transformation – based on a systematic analysis of 44 academic publications. The study proposes a structural model of university digital transformation, integrating three key dimensions: strategic management and institutional processes, technological ecosystems and pedagogical innovations, and the development of human capital. The findings demonstrate that digital transformation serves as a crucial framework for bridging the digital divide, enhancing institutional efficiency, and ensuring the sustainable development of higher education. Moreover, the proposed model contributes to the alignment of national digital policies with university strategies, reinforcing competitiveness and adaptability in the global digital environment. The study provides theoretical and practical insights for universities navigating digital transition toward sustainable growth.

Key words: digital transformation, digital education, digital transformation management, digital university, higher education, model of digital transformation, modern educational technologies, cases from leading universities, educational trends.

Introduction

Digital transformation is a comprehensive, strategic process of implementation and integration of digital technologies, developed from the initial stage of «informatization» through «digitalization», as well as becoming a full fledged concept of digital transformation today [1]. While informatization is the introduction of data processing and storage tools, digitalization is the automation and optimization of traditional processes. Digital transformation involves even more extensive changes: along with technical processes, it radically changes institutional structures, organizational models, pedagogical practices, management approaches and culture. This process creates new values, contributes to the personalization of education and management, and the sustainable development of the digital economy and Education Society. The term «digital transformation» has entered scientific circulation since the early 2010s under the influence of the concepts of Industry 4.0 and the Digital Economy [2]. The lack of consistent and clear concepts regarding the areas of application of digital transformation indicates that this phenomenon is still theoretically developing and has a different interpretation in each area. In our work, studies of digital transformation in the field of higher education, especially in relation to educational processes in universities, are considered. Digital transformation in education is a fundamental change in educational processes through the integration of digital technologies. This changed traditional practice and opened up new opportunities for learning. Digital transformation is developing rapidly due to global events such as the COVID-19 pandemic, the impact of which is multifaceted: it has radically changed teaching methods, student experience and mechanisms for managing the education system [3]. Digital transformation in education is the process of introducing modern technologies aimed at improving the quality of data collection, management and reporting. Digital transformation creates personalized and interactive learning environments to meet the specific needs of students and enable teachers to use innovative methods effectively [4]. At the same time, the transformation will ensure that higher education institutions improve educational outcomes, increase institutional efficiency and adapt to technological changes [5].

As for the basics of digital transformation, this requires the use of a platform approach to solving urgent problems of universities. This approach, along with the creation of digital platforms adapted to specific subject areas, defines management levels i.e., it is divided into digital platforms at the strategic level; digital competence centers at the tactical level; project groups at the operational level. At the same time, each level is aimed at combining the educational and scientific environment of the University with technological solutions and providing a single, comprehensive strategy for digital transformation [6]. The essence of digital transformation in higher education is the integrated communication of information technologies to improve educational processes and results. The state program of the Republic of Kazakhstan «Digital Kazakhstan» defines five main directions, including the digitalization of economic sectors and the development of human capital [7]. Key aspects include the formation of intellectual capital, the development of IT education and adaptation to new conditions caused by the pandemic. In the course of studying the practical application of digital transformation in the system of Higher Education, a research question was identified: RQ: What is the impact of digital transformation on educational practice and institutional governance in Kazakhstani higher education institutions?

The research question determine the current state of the work done and allow us to evaluate scientific contributions on the topic of digital transformation. These research questions involve the systematization of previous results by analyzing the pillars and models of digital transformation used in education. The identification or adaptation of such models becomes the starting point for research in the field of education and opens the way to the formation of a scientific and practical basis for the effective implementation of digital transformation. The main goal of the study is a comprehensive analysis of the conceptual foundations and practices of digital transformation in universities and the provision of an adapted theoretical model taking into account universal trends and national characteristics. The scientific novelty of the study is expressed primarily in the systematization of the theoretical foundations of digital transformation in the field of higher education and the identification of its evolutionary features from the stages of «informatization» and «digitalization». At the same time, international and national practices are considered within the framework of a comparative analysis, their common areas and distinctive facets are determined. In addition, at the university level, an adapted theoretical model will be developed that can be used in strategic management, pedagogical practices and institutional structures. The structure of the study consists of three main

stages: first, the evolution and theoretical foundations of the concept of digital transformation are analyzed; then international and domestic practices are involved in comparative research; at the end, a theoretical model for universities is developed and practical mechanisms for its implementation are proposed.

2. Methodology of Related Work

The methodological basis of the study is scientific publications, international strategic documents and a systematic analysis of domestic experience in the digital transformation of Higher Education. This analysis is aimed at a comparative study of foreign and national approaches, identifying the scientific and theoretical foundations of digitalization of the educational environment. To achieve the goal, a qualitative methodological approach and Grounded Theory were used [8], which makes it possible to develop a conceptual model through a systematic analysis of empirical data. Grounded theory allows this study to identify patterns, dimensions, components, participants, and relationships between them, without pre-determined hypotheses, directly from the collected data. Data were collected and analyzed through a literature review and in the field of digital transformation. This approach ensures the validity of the obtained model and accurately reflects the structural model of the digital transformation of higher education. It also provides a solid basis for analyzing digitization strategies in academia. The main keywords in the study are presented in Table 1. This table shows the keywords used in the bibliographic search system of the study and their logical relationship.

Table 1 – Main keywords in the study

Main term	Relationship to the main term
digital transformation	framework for the digital transformation, model of digital transformation, case study digital transformation
higher education	digital education, digital University
Search string used	
((«digital transformation») OR («higher education») OR («model of digital transformation») OR («digital education») AND («case study digital transformation») OR («case study digital transformation») OR («framework for the digital transformation») OR («digital University»))	

The proposed methodology consists of five stages aimed at developing a theoretical model of digital transformation in higher education, identifying and analyzing its conceptual foundations, international and domestic experience. These stages are shown in Figure 1 and presented as a practical example. This diagram is a model that structurally represents the methodological basis of the research work.
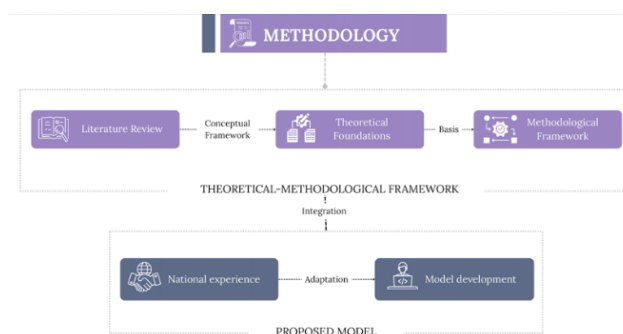

Figure 1 – Research methodology

The literature review was carried out according to the following steps: 1) search for articles using special keywords and phrases; 2) preliminary selection and filtering based on theses; 3) analysis of the relevance and availability of articles. As a result, 167 full text articles in open access (from the web of Science, Scopus and Google Scholar databases) were identified, published from 2020 to 2025. During the selection process, only research articles and conference materials were considered. 87 filtered articles were used to form the final analysis and literature review section. This stage made it possible to systematically map the initial studies. Figure 2 shows the total number of documents included in the selection – 87 articles. This visual infographic is a methodological diagram that describes the source database of the study and shows the stages of collecting, filtering, and analyzing bibliometric data.

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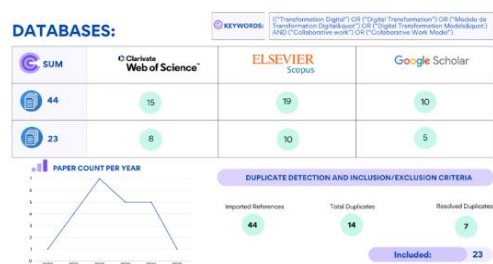Bulletin of Shakarim University. Technical Sciences № 4(20) 2025

Figure 2 – Bibliometric search results and comparative analysis of databases on digital transformation

For a deeper understanding of the essence of digital transformation, its definitions, components, areas of application and technological foundations should be studied in detail. Although the term «digital transformation» is often used in modern research [9], it differs from the concepts of «digitization» and «digitalization». Digital transformation is a profound organizational change that takes place through the use of digital technologies and models to improve the operational efficiency of an organization. This concept includes the formation of a completely new system and model, and not limited to the automation of processes, as well as the revision of the business model, strategic directions and value proposition of the institution. And digitization implies the creation of a digital representation of physical objects, and digitalization is aimed at improving activities through the introduction of automated processes. The differences between these concepts are visualized in Figure 3, making it easier to understand. This diagram shows the step by step logic of digital development.
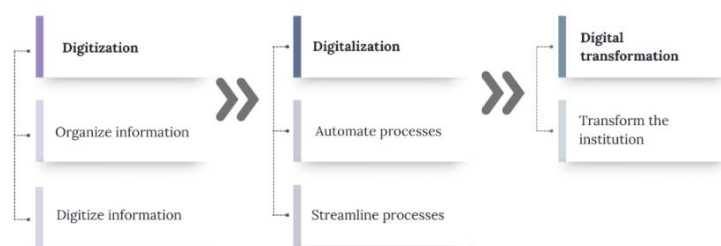

Figure 3 – Stages from digitization to digital transformation

Thus, the main features that characterize digital transformation are complexity, applicability and depth. Also, this analysis will determine the role of each technology in the education system, the gaming industry and professional training, and create a scientific basis for the effective use of their potential. Table 2 presents researchers definitions of digital transformation in higher education. The table 2 presents definitions of digital transformation in higher education given by various authors.

Table 2 – Digital transformation in higher education: meaning and interpretation

Reference	Definition of Digital Transformation in Higher Education Institutions
[10]	Digital transformation of Higher Education the introduction of new technologies aimed at improving and modernizing the practices, business models and processes of educational organizations.
[11]	The digital transformation of higher education is the integrated introduction of digital technologies in all areas of Educational, Research and knowledge dissemination activities of educational institutions.
[12]	Digital transformation in higher education is a phenomenon aimed at developing new approaches to value generation at the institutional level, providing a strategic response to processes arising under the influence of digital technologies.
[13]	The digital transformation in higher education is changing not only technology, but also the way universities operate.
[14]	The digital transformation of higher education is a significant transformation of traditional teaching and learning models as a result of the integration of technologies.

Results

Digital transformation in Kazakhstan. The introduction of digital technologies in Kazakhstan is aimed at improving the efficiency of public services, reducing bureaucratic barriers

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and improving the quality of life of citizens. Admission to universities, accommodation in dormitories and registration of NUT (National Unified Testing) results were completely transferred to electronic format, and the convenience of processes reached 92%. Digital transformation has become not just a technological modernization, but an important tool for comprehensive reform of Public Administration [15]. This Figure 4 describes the staged development of digitization and digital transformation in Kazakhstan.
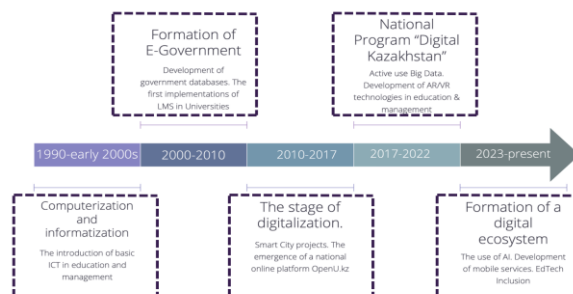

Figure 4 – Stages of development of digital transformation in Kazakhstan

Digital transformation will take place in two main directions [16]:
1) Traditional Approach – improvement of existing information systems and their gradual integration;
2) Platform approach – a radical update of management processes through the introduction of new technologies.

During this process, we focused on several key strategic tasks. These include the development of digital platforms and business models, improving the efficiency of Public Administration, promoting open government, promoting Smart Cities initiatives and strengthening infrastructure along with the national innovation system. These principles ensure the effectiveness, reliability and community oriented nature of digital transformation. They are aimed at increasing the transparency of Public Administration, strengthening citizens' confidence in the digital ecosystem, as well as improving the availability, security and quality of services.

Digital transformation in higher education in Kazakhstan. The COVID-19 pandemic has accelerated the revision of educational approaches and increased the demand for personnel with digital skills. According to Tableau, by 2025, 70% of workers will actively use data in their activities. This makes it relevant for Kazakhstan to prepare students for modern challenges [17]. The experience of digital transformation of universities in Kazakhstan, in comparison with foreign models, reveals a number of difficulties in the transition period. The results of the study divide the practice of digitalization into several categories, highlighting the need to improve online support, personalization and interaction. The article analyzes international practices and cites the strategies of Heriot-Watt University in Scotland as an advanced example. Global practice divides digitalization into three main areas: online support, personalization, and interaction. This analysis identifies gaps in these areas of Kazakhstani universities and shows the contribution of elements such as remote access, the creation of virtual learning environments and the development of web applications for online learning to the effective digital transformation of Higher Education [18].

The experience of digital transformation of universities in Kazakhstan is formed within the framework of the state program «Digital Kazakhstan», the main goal of which is to improve the quality of education through digitalization. The study revealed a number of complex problems that arise in adapting to the requirements of post industrial society and increasing competitiveness. The Global Competitiveness Index indicates the need to develop a set of strategic measures to ensure the effectiveness of the higher education system. The current situation underlines the importance of implementing systematic initiatives at the institutional level for the effective introduction of digital technologies in education and overcoming existing barriers [19]. K. Akatov (2022) [20] noted that, as part of promising initiatives, the Ministry of Science and Higher Education plans to implement a digital university model. This model is designed to transform the university's core and management processes through digital technologies. The specified model allows students to widely use personalized learning paths and courses, modern tools and online platforms. Figure 5 illustrates the «Digital university» model in Kazakhstan. This diagram illustrates the concept of the Digital University Model and highlights the four main components of a modern higher education system.
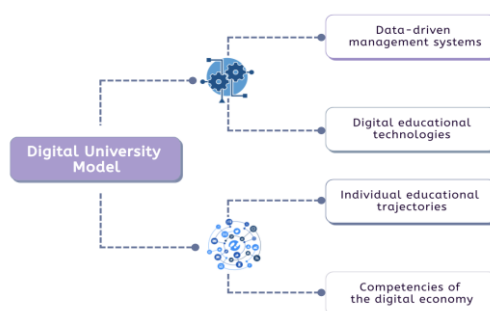
Figure 5 – Digital university model (Kazakhstan model) [20]

The results of the study showed that the experience of digital transformation of Kazakhstani universities includes the integration of modern technologies into teaching processes. This transformation is part of large scale reforms aimed at improving the quality of education and strengthening institutional efficiency. It was also noted that state policy and international cooperation played an important role in facilitating the process of digital transition. Such steps have made a significant contribution to improving academic standards and improving students ' academic achievement. Constant attention to these areas will overcome existing gaps and create the necessary prerequisites for the development of the higher education system in Kazakhstan [21].

The experience of digital transformation of Kazakhstani universities reveals the significant potential of online platforms and digital technologies in improving the quality and accessibility of Education. Currently, national and international projects aimed at the development of online education are being implemented. The results of the study prove that online courses can increase students ' motivation and contribute to improving their performance. However, there are still issues such as insufficient content quality, technical difficulties and social isolation. Overcoming these barriers is crucial for the effective implementation of digital technologies and the full use of their capabilities [22]. The success of digital transformation directly depends on the acquisition of the necessary competencies by university employees. Universities should prioritize improving the professional level of teachers by using digital educational resources and mastering new teaching methods. This ensures their flexible adaptation to innovative technologies and increases their competitiveness [23].

Digital transformation in Kazakhstan is developing in four main directions: 1) the state strategy and legal framework are being formed within the framework of «Digital Kazakhstan» and long term programs until 2030; 2) infrastructure and technologies: 5G, broadband internet, data centers, cloud solutions, IoT and artificial intelligence are being intensively introduced; 3) Personnel potential: digital competencies are being developed through IT education, retraining courses and innovation centers; 4) socio-economic: electronic services, the growth of the digital economy, support for startups and increased transparency of government processes. Figure 6 shows the main directions of digital transformation in Kazakhstan, strategy and policy, technology, social outcomes and competencies, along with their interrelationships and constituent elements. These measures will ensure comprehensive digitalization and contribute to the sustainable development of the country in the global digital economy. The diagram depicts digital transformation at the national level in terms of governance, infrastructure, human capital, and social efficiency.
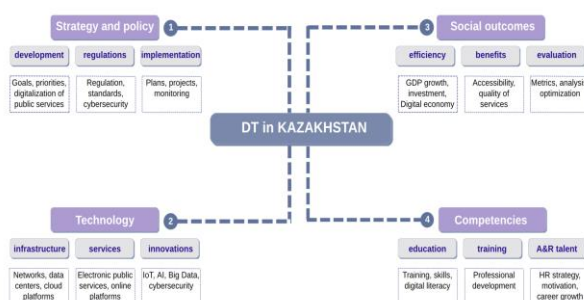

Figure 6 – Main directions of digital transformation in Kazakhstan

However, the rapid development of digital transformation can have a negative impact on traditional teaching methods: over reliance on technology is likely to reduce face to face communication and make it difficult to acquire practical skills. Therefore, the combination of quantitative and traditional methods is decisive for the integrated development of Education. Kazakhstan universities need to implement initiatives while maintaining a balance between technological capabilities and academic traditions.

Discussion

The digital transformation of universities is a multifaceted and continuous process that extends beyond the mere introduction of new technologies to encompass structural, cultural, and strategic transformations. This study conceptualizes digital transformation as a systemic and holistic phenomenon that integrates management, the technological ecosystem, and pedagogical innovation within the higher education system. While previous research has often addressed isolated aspects such as digital infrastructure, online learning environments, or e-governance, this study provides a comprehensive examination of their interrelationships. The scientific significance of the research lies in the development of a comprehensive structural model that bridges theoretical foundations and practical applications of digital transformation in higher education. Figure 7 presents a structural logical model of digital transformation in Kazakhstan's higher education system, illustrating the core directions and their interconnections based on the proposed extended framework. The model demonstrates the interaction among three key dimensions strategic management, the technological ecosystem, and pedagogical innovation thereby expanding the theoretical understanding of digital transformation and establishing a methodological basis for its practical implementation in universities.
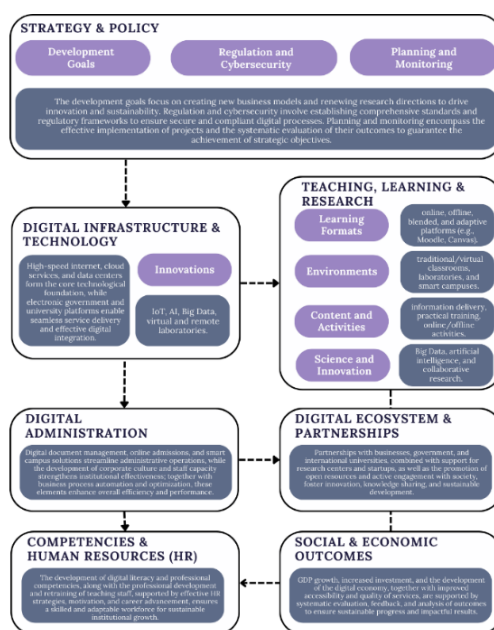

Figure 7 – Structural model of digital transformation of higher education

Importantly, this structural model also reflects the sustainable development perspective of higher education. Digital transformation contributes to the long term sustainability of universities by enhancing institutional resilience, promoting inclusivity, and supporting continuous human capital development. Through intelligent governance, efficient resource management, and digital competencies, universities strengthen their adaptability to global challenges while maintaining educational quality and accessibility. In this sense, digital transformation is not only a technological or organizational modernization but also a strategic mechanism for ensuring the sustainable development of higher education, aligning with the Quality Education, Industry, Innovation, and Infrastructure. Furthermore, the model ensures coherence between national digitalization policies (such as the Digital Kazakhstan program) and institutional strategies, thus fostering a balance between stability and adaptability in the ongoing transformation of higher education.A comparative analysis of Kazakhstani practices has revealed several distinct advantages of the proposed model. Its primary strength lies in the integration of technological modernization with pedagogical transformation, positioning the university not merely as a consumer of technology, but as a formative

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and innovative agent within the broader educational ecosystem. By placing human capital development at the center of digital transformation, the model enhances its practical relevance, fostering a learning environment that promotes digital literacy, professional growth, and innovative thinking.

From a theoretical perspective, this study deepens the understanding of digital transformation as a multi-level, iterative, and interdependent process. It reconceptualizes digitalization not solely as a technological phenomenon, but as a strategic and socio-pedagogical paradigm, thereby establishing a new scientific approach that functions as a mechanism for the sustainable development of higher education. From a practical standpoint, the proposed model provides universities with a diagnostic and developmental tool that enables them to evaluate their level of digital maturity, identify systemic weaknesses, and formulate targeted measures to enhance institutional performance and adaptability.

Overall, the findings of this research confirm that the success of digital transformation in higher education depends not only on infrastructure and policy frameworks, but also on the harmonious interaction between technological capacity, institutional leadership, and human potential. The model proposed in this study is distinguished by its scientific novelty and applied value, serving as a strategic framework for achieving sustainable digital transformation in Kazakhstani universities and contributing to the country's long term educational and socio-economic advancement.

Conclusion

Research shows that digital changes in higher education are not limited to the introduction of new technologies. It also requires a radical update of the University's management system, teaching methods and organizational work in general. An analysis of the International and Kazakhstan experience showed that for successful changes, it is important to maintain a balance of world trends and national characteristics. The proposed model includes three main areas: strategic management of the University and regulation of internal processes; development of technological systems; pedagogical innovations, that is, increasing the competence of teachers and improving students knowledge. This model not only helps to reduce the digital gap and improve the efficiency of the university, but also to adapt them to the global digital environment and make them more competitive. For Kazakhstan, alignment between state policy and institutional initiatives is essential to achieve a sustainable digital university model.

In the future, it is planned to analyze the experience of digital transformation in universities in Kazakhstan using the methods of empirical research, scenario modeling and Case Analysis. Thus, digital transformation in higher education is, on the one hand, a great opportunity, on the other hand, a serious challenge, as it radically changes the functioning of universities and opens the door to the formation of new educational practices. Combining international best practices with national strategies, Kazakhstan can develop competitive and innovative universities and give a significant impetus to the digital economy and sustainable development of the country.

In conclusion, digital transformation must be regarded as a continuous, adaptive, and holistic process whose success depends on the strategic integration of technology, governance, and pedagogy. This integrated approach ensures the sustainable development of higher education, reinforcing Kazakhstan's role in the global knowledge economy and supporting its transition toward an innovative and inclusive digital society.

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ЖОҒАРЫ БІЛІМ БЕРУДІ ТҰРАҚТЫ ДАМЫТУ ҮШІН ЦИФРЛЫҚ ТРАНСФОРМАЦИЯ

Жоғары білім саласындағы цифрлық трансформация тек технологиялық жаңғыртумен шектелмейтін стратегиялық және кешенді өзгеріс болып табылады, ол институционалдық құрылымдарды, басқару тәжірибелерін және педагогикалық тәсілдерді қамтиды. Бұл зерттеу жұмысында біз Қазақстандағы цифрлық трансформацияның эволюциясын, атап айтқанда информатизациядан және цифрландырудан толыққанды трансформацияға дейін 44 жарияланымды (оның ішінде 23 зерттеуді) жүйелі талдау арқылы қарастырамыз. Алынған нәтижелер университеттердің цифрлық трансформациясының құрылымдық моделін ұсынамыз, сонымен қатар цифрлық трансформация үш аспектіні біріктіреді: стратегиялық басқару мен институционалдық процестер, технологиялық экожүйелер мен педагогикалық инновациялар, сондай-ақ адами капиталды дамыту болып табылады. Бұл модель цифрлық алшақтықты азайтуға, институционалдық тиімділік пен бәсекеге қабілеттілікті арттыруға арналған негіз ретінде қызмет етеді.

Түйін сөздер: цифрлық трансформация, цифрлық білім беру, цифрлық трансформацияны басқару, цифрлық университет, жоғары білім, цифрлық трансформация моделі, заманауи білім беру технологиялары, жетекші университеттердің кейстері, білім беру *үрдістері.*

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ЦИФРОВАЯ ТРАНСФОРМАЦИЯ ДЛЯ УСТОЙЧИВОГО РАЗВИТИЯ ВЫСШЕГО ОБРАЗОВАНИЯ

Цифровая трансформация в высшем образовании представляет собой стратегический и комплексный сдвиг, выходящий за рамки простой технологической модернизации и охватывающий институциональные структуры, управленческие практики и педагогические подходы. В данной исследовательской работе мы рассмотрим эволюцию цифровой трансформации в Казахстане, в частности, от информатизации и оцифровки до полноценной трансформации посредством системного анализа 44 публикаций (в том числе 23 исследования). Полученные результаты представляют собой структурную модель цифровой трансформации университетов, при этом цифровая трансформация объединяет три аспекта: стратегическое управление и институциональные процессы, технологические экосистемы и педагогические инновации, а также развитие человеческого капитала. Эта модель служит основой для сокращения цифрового разрыва, повышения институциональной эффективности и конкурентоспособности.

Ключевые слова: цифровая трансформация, цифровое образование, управление цифровой трансформацией, цифровой университет, высшее образование, модель цифровой трансформации, современные образовательные технологии, кейсы ведущих университетов, образовательные процессы.

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