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STRUCTURAL AND FUNCTIONAL ANALYSIS OF THE KEY ELEMENTS OF THE DIGITAL UNIVERSITY MODEL

СТРУКТУРНО-ФУНКЦІОНАЛЬНИЙ АНАЛІЗ КЛЮЧОВИХ ЕЛЕМЕНТІВ МОДЕЛІ ЦИФРОВОГО УНІВЕРСИТЕТУ

The digital transformation of higher education is driven by the rapid development of information and communication technologies, which promotes to optimize management processes, improve the educational environment and personalize learning. However, existing models of digital universities consider only certain aspects of digitalization, which makes it difficult to form a single digital ecosystem. The aim of the research is to analyze the structural and functional analysis of the key elements of the digital university model and determine the optimal approaches to their integration. A five-level model of a digital university is proposed, which includes stakeholders in the educational process, information infrastructure, research laboratories, digital marketing, and advanced technological solutions. The results of the research can be used to develop strategies for the digital transformation of universities, adapt curricula to the requirements of the digital economy, and improve digital mechanisms for managing the educational process. Further research should be aimed at improving methodological approaches to the digitalization of educational environments, evaluating the effectiveness of digital solutions, and developing adaptive models for managing digital universities in the context of global integration of the educational space.

Keywords: digital university, digitalization of education, digital technologies, digitalization, digital transformation.

Сучасний етап розвитку вищої освіти характеризується масштабними цифровими трансформаціями, що відбуваються під впливом стрімкого розвитку інформаційно-комунікаційних технологій. Запровадження цифрових рішень у діяльність університетів сприяє оптимізації управлінських процесів, удосконаленню освітнього середовища та створенню персоналізованих траєкторій навчання. Проте наявні моделі цифрових університетів здебільшого розглядають лише окремі аспекти цифровізації – дистанційне навчання, автоматизацію адміністративних процесів або інтеграцію штучного інтелекту. Недостатня системність підходів до цифрової трансформації ускладнює формування єдиної цифрової екосистеми закладів вищої освіти, що зумовлює необхідність розроблення комплексної моделі цифрового університету. Метою дослідження є структурно-функціональний аналіз ключових елементів моделі цифрового університету та визначення оптимальних підходів до їх інтеграції в освітній, науково-дослідний і управлінський процеси закладів вищої освіти. У статті використано методи системного аналізу, порівняльного аналізу, узагальнення теоретичних підходів та абстрактно-логічний метод для формулювання концептуальної моделі цифрового університету. Результати дослідження підтверджують, що цифровізація університетської освіти передбачає не лише впровадження інформаційних технологій, а й комплексне переосмислення освітнього процесу та організації діяльності університетів. Запропоновано п'ятирівневу модель цифрового університету, яка охоплює: 1) стейкхолдерів освітнього процесу, 2) інформаційну інфраструктуру закладу, 3) дослідницькі лабораторії та інноваційні центри, 4) цифрові маркетингові інструменти, 5) передові технологічні рішення, зокрема штучний інтелект, блокчейн і доповнену реальність. Результати дослідження можуть бути використані для розроблення стратегій цифрової трансформації університетів, адаптації навчальних програм до вимог цифрової економіки та удосконалення цифрових механізмів управління освітнім процесом. Подальші дослідження мають бути спрямовані на удосконалення

методологічних підходів до цифровізації освітніх середовищ, оцінку ефективності впровадження цифрових рішень та розроблення адаптивних моделей управління цифровими університетами в умовах глобальної інтеграції освітнього простору.

Ключові слова: цифровий університет, цифровізація освіти, цифрові технології, діджиталізація, цифрова трансформація.

Statement of the problem. The current stage of higher education development is characterized by profound transformational processes caused by the digitalization of the educational space and the introduction of the latest information and communication technologies. Universities are actively adapting digital solutions, but their integration is often fragmented, which makes it difficult to form a coherent digital ecosystem of a higher education institution. Existing models of the digital university are mostly focused on certain aspects of digitalization, such as automation of administrative processes, distance learning, or the use of artificial intelligence, but do not sufficiently take into account the structural and functional relationships between the key elements of digital transformation.

Considering this, there is a need for a systematic analysis of the digital university model, which covers the structural levels of its functioning, mechanisms of digital interaction between the subjects of the educational process, and the economic feasibility of digital technologies. The lack of single approaches to organizing digital educational environments, as well as the need to optimize the processes of their integration into the management and scientific and educational activities of the university, determine the relevance of this research.

Analysis of recent research and publications. The issues of university education digitalization and its structural and functional analysis are studied in the works of many scholars. Considerable attention is paid to the issues of digital transformation of the educational process in the works of Sklyarenko O.V., Yahodzynskyi S.M., Nikolayevskyi O.Y., Nevoroz A.V. [1], who consider digital interactive learning technologies as an integral part of the modern university environment.

Some aspects of digital transformation in education are studied in the works of Dushchenko O. [2], who studies the current state of digitalization in the learning process, and Khomenko O.O., Paustovska M.V., Onyshchuk I.A. [3], who analyze the impact of interactive technologies on the learning and development of students. Verina N., Titko J. [4] develop conceptual approaches to digital transformation, and Karpliuk S.O. [5] focuses on the peculiarities of educational process digitalization in higher education institutions.

The study of digital economic systems and their impact on education is presented in the works of Lopuschnyak H.N., Chala O., Poplavska O. [6], who analyze the socio-economic determinants of the digital ecosystem of sustainable development. At the same time, Williamson B., Eynon R., Potter J. [7] consider the relationship between digital technologies, distance education, and pedagogical practices in a pandemic.

Despite a significant body of scientific publications, a comprehensive structural and functional analysis of the digital university model remains insufficiently developed, which necessitates further research on this topic.

Formulation of the research task. The aim of the research is a structural and functional analysis of the key elements of the digital university model and determination of optimal approaches to their integration into the educational, scientific and research, and management processes of higher education institutions.

To achieve this aim, the methods of system analysis were used to assess the relationships between the structural components of a digital university, the method of comparative analysis to study existing approaches to the digitalization of educational institutions, methods of analysis and synthesis to summarize theoretical approaches to the development of the university's digital ecosystem, and the abstract and logical method to formulate conclusions and justify the conceptual model of a digital university.

Summary of the main research material. The educational sphere at the present stage of society's development is being formed in the context of globalization processes that cover both economic and educational space [8, p. 1]. The implementation of widely accessible digital learning platforms that accumulate educational resources from the world's leading universities ensures the integration of scientific knowledge into the global educational landscape. The use of modern information technologies promotes a significant acceleration of access to the necessary scientific materials that were previously available only to a limited number of researchers. In addition, automated translation systems play an important role in overcoming language barriers, enabling the expansion of scientific interaction and adaptation of information content to the specifics of subject research.

The transition to digital education is one of the most pressing issues facing the management structures of modern universities. The process of digitalization is not limited to the transformation of educational content into a digital format or the creation of distance learning courses. Its implementation requires a structural rethinking of approaches to the organization of the learning process, revision of personnel policy due to the need to develop digital competencies of the teaching staff, and adaptation of the university's internal business processes to the conditions of the digital ecosystem. In order to achieve compliance of digital transformation with the strategic objectives of the educational sphere development, it is necessary to implement a comprehensive digitalization model that integrates technologies, methodological principles, and management tools into a single university information system.

Under the digitalization of an educational organization, we understand the end-to-end automation of all major business processes and university services and the reorientation of all key structural units of an educational organization to work together in a single automated (digital) space [9, p. 52]. However, with traditional automation, when different structural units or business processes implement their own automation tools, there is a risk of not achieving the required efficiency from the implementation of such a “digital solution”. Internal contradictions between business processes, as well as

incompatibility of data formats between individual modules of different information systems can negate all the benefits of educational organization digitalization [10, p. 9]. Thus, the university digitalization also implies a complete (or partial, if the university has previously reoriented itself to business process automation) reengineering of all business processes based on the implementation of modern digital technologies.

Modern economic transformations, education globalization processes, and the prospects offered by digitalization provide universities with new opportunities and tools to improve the efficiency of the educational process. In particular, digital technologies promote:

– individualization of learning, which allows students to master educational programs at their own pace, regardless of time zones and territorial location of the university;

– minimization of costs for printed materials, as educational programs are implemented exclusively in the digital environment;

– reduction of material costs of universities, as the financial costs of implementing educational programs no longer depend on the number of students [11; 12].

At the same time, the transition to the digital university model requires teachers, students, and management structures of an educational organization to acquire new competencies. According to S.O. Karpliuk, "the key competencies of an educational institution are a set of factors that ensure its competitiveness" [5, p. 90]. According to this approach, the formation of key competencies of a digital university requires the implementation of a number of priority measures:

– professional development of all academic staff, especially in universities that do not specialize in information technology [13; 14];

– development of incentive mechanisms for teachers who actively use digital technologies in the educational process and develop their own digital competencies;

– systematic support for teachers who have an insufficient level of competence in the field of information technology [15, p. 77];

– large-scale transformation of university infrastructure and internal business processes;

– implementation of personalized educational trajectories for students;

– widespread use of digital teaching methods, in particular massive open online courses and distance technologies for intermediate control knowledge.

The study of the key competencies of a digital university and the implementation of measures aimed at achieving them actualizes the need to develop a concept of a digital university, which may consist of five levels (Figure 1).

The first level of the digital university model includes the main stakeholders of the educational process, in particular, scientific and pedagogical staff, students, applicants, graduates and employers, each of whom has specific requirements for university education [16, p.69]. For applicants, the main criterion is the quality of educational programs that ensure professional competitiveness. At the same time, employers expect higher education institutions to adapt their curricula to the current requirements of the labor market, which implies close integration of academic studies with professional practice.

The second level of the digital university model is represented by the information base of the higher education institution, which includes library services, internal information systems, digital learning platforms, and automated workspaces for teachers. This environment

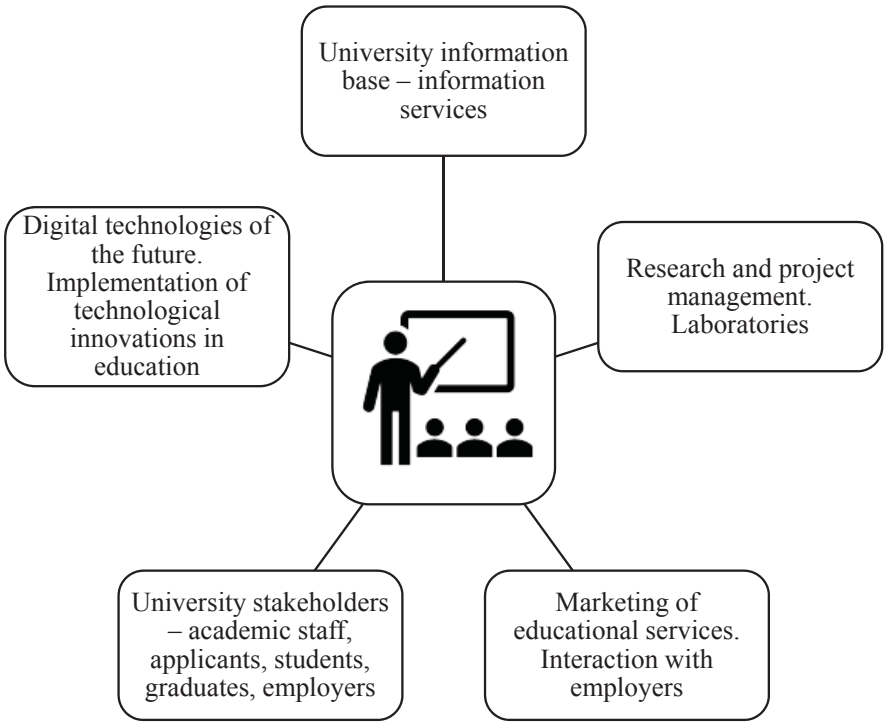

Figure 1. Levels of the digital university model

Source: created by the author independently

forms an integrated infrastructure that supports efficient access to educational and scientific resources.

The third level includes research laboratories and educational and research centers, which are the foundation of the university's innovative development. An important component of this level is to provide favorable conditions for research and effective dissemination of their results. For this purpose, it is necessary to implement digital research management systems, platforms for accounting for scientific publications, and automated systems for presenting scientific achievements at international conferences. In addition, mechanisms for rapid implementation of research results in training courses should be provided, which will help to update educational programs according to current scientific trends.

The fourth level of the model is focused on the development of digital marketing tools that promote educational programs and the university as a whole. This involves the widespread use of automated platforms for registering applicants, digital services for conducting entrance exams, and the creation of individual educational trajectories based on an analysis of students' needs.

The fifth level of the model, which remains insufficiently studied, includes the implementation of advanced technological solutions in the field of education. An example of such innovations is the use of autonomous drones for the logistics of educational materials at the Massachusetts Institute of Technology (MIT). Further development of this level involves the experimental application of artificial intelligence, blockchain technologies, and virtual reality systems in the educational process.

The graphical concept of the digital university model is shown in Figure 2.

The "Digitalization of educational programs" subsystem (Figure 2) contains a detailed description of research activities and strategic initiatives that, according to the authors, are critical for the effective transition to digital technologies in higher education. First of all, it is the diversification of educational programs, which should be based on current socio-economic trends and forecasts of labor market transformation. It is important not only to adapt programs according to changes in professional activities, but also to integrate the best practices of leading

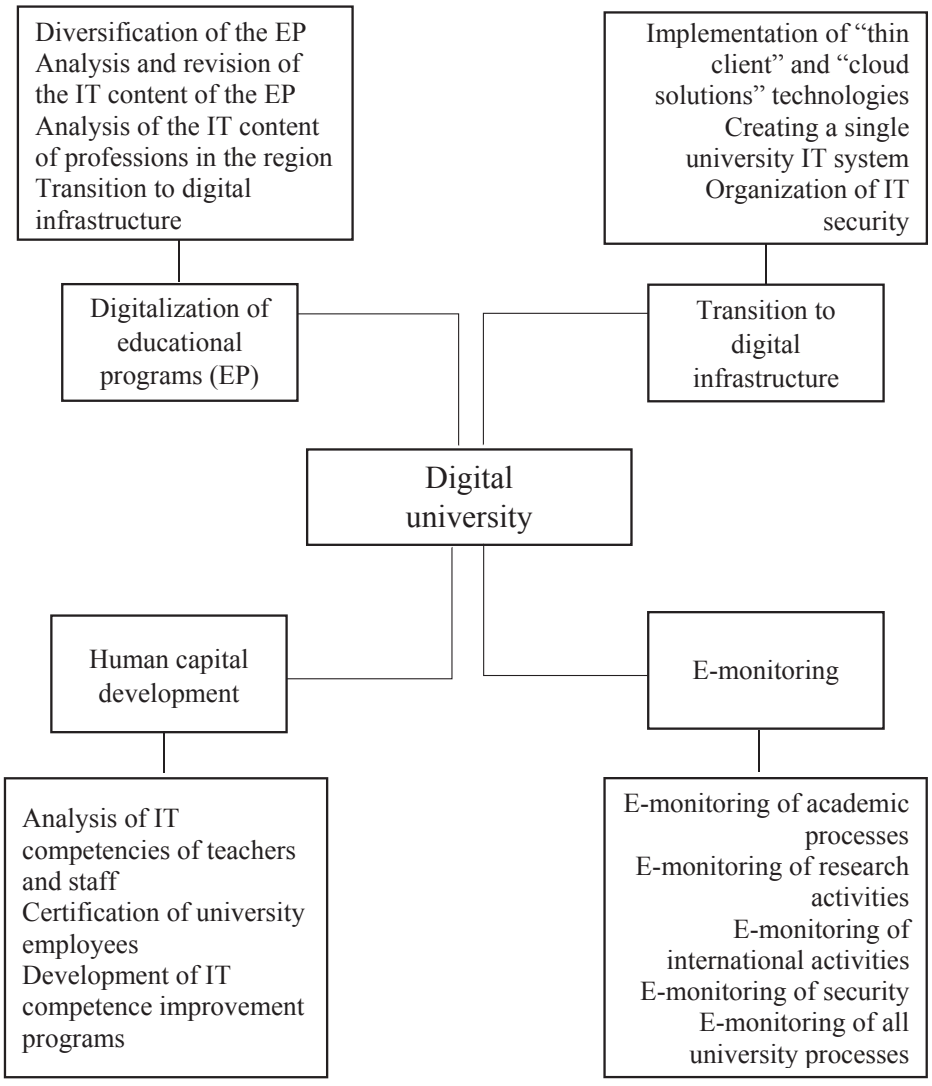

Figure 2. Graphic concept of the digital university model

Source: created by the author independently

universities that actively implement digital approaches in the learning process.

Updating the content of existing educational programs is also a key task of the university, as it must be carried out taking into account the requirements of employers, as well as new opportunities offered by modern software and hardware. It is important not only to take into account the expectations of potential employers, but also to involve them in the direct development of educational programs, if possible.

Equal in importance to other areas of digital transformation, but the most ambitious in its content, the "Transition to digital infrastructure" area provides a set of measures aimed at the global restructuring of all business processes of the university and the digitalization of its structural units. In the ideal case, university activities should be organized based on a single information system [14; 16] However, given the high level of complexity of developing such a system by the university on its own, it is recommended to use ready-made solutions available on the information technology market that are adapted to the specifics of higher education (e.g. EUni) [17].

One of the key components of this system is the module for monitoring university business processes, which is tasked with collecting and analyzing data in real time using Big Data technologies. This module allows for comprehensive monitoring of the activities of faculties and departments, tracking the university's research activities, controlling security (video surveillance systems, access control, fire safety), and analyzing the functioning of local networks and communal infrastructure of the institution.

The implementation of the paper-free concept is another important area of university digitalization. The implementation of this concept involves the creation of an electronic document management system that will automate the approval and processing of internal documents. At the same time, the share of documents processed in the electronic system should be at least 80% of the total document flow of the university.

The development of a "single window" system and mobile university infrastructure is an important solution in the context of removing administrative barriers for students and university staff. In this regard, it is advisable to create a universal information system that allows for centralized management of access to educational and administrative services, as well as integration of mobile technologies to improve the efficiency of management processes.

The concept of access to educational content on a "single window" basis can be realized through the integration of university platforms with international online courses and educational resources such as edX, Coursera, etc. One of the important aspects of digital transformation is to ensure the "single registration" principle, which allows students to be authorized once, gaining access to all digital educational resources integrated into the university system. This approach will promote the formation of personalized educational trajectories and expand distance learning opportunities.

Conclusions. Digitalization of university education is one of the key areas of the educational process modernization in the context of globalization changes. The implementation of digital platforms and automated management systems helps to expand access to educational resources, individualize students' educational trajectories, and improve knowledge control mechanisms. At the same time, digital transformation creates new challenges related to the need to adapt teachers and students to new learning formats, as well as to ensure an adequate level of cybersecurity and personal data protection in the digital environment.

The analysis of the key elements of the digital university model has shown that the digitalization of higher education institutions significantly affects the organization of the learning process and the interaction of its participants. The implementation of innovative digital technologies, such as automated educational platforms, analytical systems for monitoring learning achievements, and adaptive learning environments, allows to increase the efficiency of the educational process. An important aspect is also to ensure the continuous updating of the university digital infrastructure and the integration of new technological solutions into the learning and research process.

Further research in the field of the digital university should be aimed at improving the mechanisms for integrating already implemented digital technologies and assessing their impact on the quality of education and research. In particular, the issue of effective use of artificial intelligence to personalize curricula, improve blockchain solutions for academic data management, and expand the capabilities of virtual and augmented reality in the educational process is relevant. Another important task is to develop universal standards for digital education that will help harmonize digital approaches in higher education and ensure their compliance with current challenges and global educational trends.

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