

СЕКЦІЯ І. ЕКОНОМІЧНА ТЕОРІЯ, МАКРО- ТА РЕГІОНАЛЬНА ЕКОНОМІКА

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DIGITAL MATURITY AS A KEY FACTOR IN THE DIGITAL UNIVERSITY TRANSFORMATION

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The rapid pace of the education digital transformation requires a comprehensive analysis of the effectiveness of various digital technologies, as well as changes in the paradigms of interaction between the educational system and key stakeholders - the state and society. A philosophical understanding of the essence of the education digital transformation is necessary nowadays to develop strategies aimed at optimizing educational processes and meeting the needs of modern society.

The issues related to the strategy and tactics of education digitalization are of great importance for theorists, practitioners, society and the state [1, p.30]. In this context, the discussion of theoretical and practical aspects related to the concept of digital maturity (DM) of education becomes an important thematic area. The digital maturity of education is gaining the role of a conceptual focus and a basic concept for analyzing and understanding the nature and essence of digital transformations in modern society and the educational environment.

The theoretical understanding of the concept of digital maturity of education provides an opportunity to systematize a wide range of “digital” challenges and tasks, allowing to focus on the key issue - determining the role and place of digital transformation of modern society and education in the context of the general logic of current and future technological revolutions known as Industries 4.0 and 5.0.

The concept of “digital maturity”, which emerged as part of theoretical discussions about Industry 4.0, initially referred exclusively to the economic and management aspects of market economy development [2, p.127]. Over time, this concept has been adapted for use in the educational sphere, which ensured its integration into the context of analyzing the education digital transformation. The starting point is that the concept and theoretical concept of digital maturity, which are in the process of active formation, have the potential to become key guidelines in the development and implementation of optimal strategies for the education digital transformation [3; 4].

It is fundamental that the definition of the level, nature and essence of digital maturity actually sets the goals, tasks and stages of education development and its subjects in the process of large-scale digitalization of the industry. Digital maturity acts as a kind of compass, guided by which subjects of educational activities will form their own trajectory towards the digital ideal. The success or failure of a state strategy for large-scale education digitalization directly depends on the level of digital maturity achieved.

Obviously, the concept of digital maturity, as defined by Industry 4.0, will not remain unchanged in the context of the development of economic systems and subsequent technological revolutions. Based on this, it can be argued that the criteria for digital maturity in education cannot be static. They must be constantly adapted to new technological realities and the requirements of society.

The digitalization of industries in different countries usually occurs at different speeds, which leads to different levels of digital maturity [5, p.8]. Despite the widespread use of the concept of digital maturity in practice, this concept has not yet received a stable and conventional interpretation in scientific circulation. There are different definitions in different sources. Thus, S.M. Yahodzynskyi defines digital maturity as “a key indicator of the level of digital development”, which may reflect the readiness for management changes, the ability of an enterprise to offer customers a quality product or effectively provide and control public services [6, p.78].

In turn, E. Tocto-Cano, S. Paz Collado, J.L. López-Gonzales, J.E. Turro-Chaparro interpret digital maturity as a tool that is widely used in software development, which has spread to such industries as education, healthcare, energy, finance, public administration and general use [7, p.99].

The general context of foreign research on the digital maturity of economic industries is determined by the ideas of its assessment using

conceptual models, for example, the model of “measuring digital maturity” [7] or the methodology for prioritizing elements in the structure of digital maturity for higher education institutions (DMFHEI) [8]. Methods of capturing the digital maturity of universities, such as “Analytic Network Process (ANP)” and “Decision EXpert (DEX)” are also used [9]. The results of applying these models demonstrate the possibility of systematizing digital transformation processes, contributing to the increase of efficiency in various industries of the economy, including education. Among the most well-known and widespread models are The Digital Maturity Model 4.0 and the Deloitte Digital Maturity Model [7;9].

Despite the growing need to assess digital maturity in various industrial industries, the education segment remains underrepresented in terms of assessing its digital maturity, which limits the effectiveness of digital university transformation.

It is obvious that all available assessment methods today are focused exclusively on the following aspects:

- collection and processing of fixed quantitative indicators of digital maturity, mainly at the micro level;
- assessing the digital maturity of a particular industry with details of its key indicators;
- performing labor-intensive tasks of collecting, processing, and analyzing data to assess the digital maturity of an industry.

To improve existing approaches and complement them, we can propose a macro-level assessment of digital maturity based on an innovative research ideology. Its basic elements are the concept of technological permeability and unified indicators that are independent of a particular industry (environmental resistance, number of digital technologies, technology applicability ratio, etc.).

A distinctive feature and advantage of the proposed methodology is the absence of significant time, human resources and financial costs for assessing the digital maturity of the industry.

Our proposed macro-level approach to assessing the digital maturity of education is based on the author's concept of technological permeability and the adoption of the introduction of technology integrators of digital twins or avatars into the educational process as a criterion for achieving maximum digital maturity. It is proposed to determine the technological permeability of the industry in the period of Industry 4.0 using the formula:

$$T\Pi_p = k_B * \frac{K_T}{O_{cp}} \quad (1)$$

where:

$T_{\text{п}}$ – *technological permeability of the industry*;

$k_{\text{в}}$ – *number of digital technologies implemented*;

$K_{\text{т}}$ – *coefficient of digital technology applicability*;

$O_{\text{ср}}$ – *environmental resistance (education or another industry)*.

In other words, the technological permeability of the industry is defined as the ratio of the number of digital technologies implemented to the industry environment resistance, adjusted for the coefficient of digital technology applicability in a particular industry. This formula allows to assess the industry's ability to adapt digital innovations and identify the main barriers to their implementation.

In this sense, the digital maturity of the Industry 4.0 period can be expressed by the following formula:

$$\text{ЦЗ}_{\text{г}} = T_{\text{п}} * k_{\text{в}} \quad (2)$$

where:

$\text{ЦЗ}_{\text{г}}$ – *digital maturity of the industry*;

$T_{\text{п}}$ – *technological permeability*;

$K_{\text{в}}$ – *technology implementation ratio*.

In our case, the digital maturity of education (of the Industry 4.0 period) is mathematically defined as the product of the technological permeability of the educational environment and the digital technology implementation ratio, which reflects their relevance and further efficiency of use.

Essentially, the digital maturity of education is an integral characteristic of the process of implementation and application of end-to-end digital technologies that contribute to the formation of an innovative educational environment and optimization of its functioning in the context of digital transformation [10, p.809].

The absolute criterion for achieving the maximum level of digital maturity of education in the context of Industry 4.0 is not only the fact of implementation and use of individual digital technologies, but also the integration of end-to-end technologies, in particular digital avatars, into key educational processes. Within this approach, each technological mode, starting with Industry 4.0, which creates specific challenges and expectations for education, corresponds to a certain level of digital maturity of education.

The key challenges of Industry 4.0 are to ensure the effective implementation and use of end-to-end technologies in order to:

- maximum automation and unification of processes;
- significant reduction in the cost of creating educational products and services;

- optimal satisfaction of market demand for high-quality educational products at the lowest price by digitalizing hazardous and routine processes.

Industry 5.0, which follows Industry 4.0, puts forward new requirements for educational systems, focusing on the humanization of economic and socio-cultural communications [11;12]. It involves the transition from mass production of standardized educational products to their personalization and individualization. In this regard, the digital maturity of education in the context of Industry 5.0 is fundamentally different from its characteristics in Industry 4.0.

In the context of Industry 5.0, the main indicators of digital maturity are individualization, personalization and customization of educational processes [13, p.314]. The main assessment criterion is shifting from quantitative indicators of the implementation of digital technologies to the analysis of their effectiveness in meeting the needs of customers and consumers of educational products and services.

At the same time, Industry 5.0 does not deny the achievements of Industry 4.0, but focuses on changing value orientations, integrating previously implemented end-to-end technologies into new socio-cultural paradigms. While Industry 4.0 prioritized standardization, unification, and technological efficiency, Industry 5.0 determines the degree of compliance of digital technologies with society's demands for education with a “human face”.

Unified educational products, no matter how high-quality, affordable, or effective they may be, will eventually lose their relevance in the global educational environment. This is driven by the growing demand for educational solutions that take into account individual needs, personalization, and a value orientation towards uniqueness, which is in line with the key ideas of Industry 5.0.

One of the ways to implement these requirements is to introduce technologies capable of creating individualized digital models of educational system objects that adapt to the specifics and needs of each participant in the educational process. Obviously, the priority tasks in the process of creating digital avatars in education are the development of “digital replicas” of such educational subjects and objects as students, teachers, structural units, educational institutions and various activities in research and education

systems. In this context, it is important to analyze the necessary and sufficient conditions without which the construction of digital avatars in the education system is impossible. It is worth emphasizing that the methodological approach to creating educational reality using digital avatar technology should take into account not only technical aspects but also the socio-cultural specifics of the objects for which the virtual model is being developed.

A digital avatar of the educational object can be created under the following conditions:

1. Building a mathematical model of the object or phenomenon for which the “digital avatar” is created (all processes should be described in the language of mathematics).
2. Development of the necessary technical means for collecting, processing and storing data on a social object (in particular, specialized software).
3. Real-time collection of information that is accumulated, corrected and transmitted to the virtual avatar.
4. Implementation of the “digital avatar” adjustment mode (the created digital model can be finalized and used to provide feedback to a real social object).
5. Formation of a theoretical and methodological basis for researching the implementation of digital technologies in educational reality and analyzing their effectiveness.

Necessary stages of creating the digital avatar in education:

Preparatory stage. Identification of the object or process for which the digital avatar is being developed, with the identification of all its internal and external characteristics. Formation of an electronic passport of the object, including the digitalization of all necessary documents, technical specifications, drawings, mathematical models, etc.

Data collection stage. Determining the types and amounts of data about the object, ways to collect, process, and store it. For example, using information from sensors, video cameras to track pupil movements while reading, data on room temperature, typing speed, etc. Design development of a digital model.

Development stage. Creation of the digital avatar, development of a software system taking into account all the selected characteristics of the object.

Implementation, verification and adjustment stage. Launching the digital avatar into operation to analyze and process the received data, compare it with template values, and identify problems and differences. Based on artificial

intelligence, the avatar generates solutions and creates reports for developers in a given format.

Therefore, the implementation of the concept of digital avatars in the educational environment will open up wide opportunities for transforming educational processes, increasing their efficiency and adaptability. It will ensure the creation of flexible models of interaction between participants in the educational process, optimization of management decisions, as well as personalization of training according to the individual needs of each student. At the same time, the introduction of digital avatars will contribute to the development of innovative approaches to the evaluation, monitoring and analysis of educational activities, creating the basis for the implementation of key ideas of Industry 5.0 and meeting the current challenges of the digital age.

Therefore, achieving digital maturity in the educational environment is a prerequisite for the effective transformation of a digital university, as this concept allows for the creation of development strategies that synchronize technological innovations with the individual educational needs of students. It is important that the integration of digital technologies includes the personalization of educational processes, which allows adapting educational models to the requirements of each participant in the educational process. Digital maturity, therefore, not only indicates the level of technological readiness, but also ensures the development of the university, focusing its activities on the integration of advanced technologies as part of Industries 4.0 and 5.0.

Thanks to the concept of technological permeability and the use of digital avatars in the educational process, universities can significantly increase the efficiency of management decisions, optimize educational programs and ensure high adaptability to the needs of society. The implementation of such innovations will allow universities to remain competitive in the global education market, meeting the challenges of the digital age. Approaches based on the concept of digital maturity can become the basis for sustainable development of education, helping to create individualized learning trajectories and ensure the flexibility of the educational process in the conditions of constant technological evolution.

References:

1. Kozhyna, A. Reducing Poverty, Inequality and Social Exclusion in European Countries. *Based on Inclusive Approaches to Economic Development*. Economics and Management of The National

- Economy, The Crisis of National Models of Economic System, 2022. Pp.29-32. DOI: <https://doi.org/10.30525/978-9934-26-269-2-7>.
2. Філософія освіти: навчальний посібник. – 2-ге видання / за наук. ред. академіка В. П. Андрущенко та ін.. Київ: Вид-во НПУ імені М. П. Драгоманова, 2021. 348 с.
 3. Колодінська Я.О., Скляренко О.В., Ніколаєвський О.Ю. Практичні аспекти розробки інноваційних бізнес ідей з використанням цифрових сервісів. *Економіка і управління*. 2022. № 4. с. 53-60. DOI: <https://doi.org/10.36919/2312-7812.4.2022.53>.
 4. Скляренко О.В., Ягодзінський С.М., Ніколаєвський О.Ю., Невзоров А.В. Цифрові інтерактивні технології навчання як невід’ємна складова сучасного освітнього процесу. *Інноваційна педагогіка*. 2024. № 68 (2). с.51-55. DOI: <https://doi.org/10.32782/2663-6085/2024/68.2.51>.
 5. Lopuschnyak, H. N. Chala, O. Poplavska. Socio-economic determinants of the ecosystem of sustainable development of Ukraine. *IOP Conf. Series: Earth and Environmental Science*, 2021. 1. C.1-9. DOI: <https://doi.org/10.1088/1755-1315/915/1/012019>.
 6. Ягодзінський С.М. Глобальні інформаційні мережі у соціокультурній перспективі: монографія. К.: Аграр Медіа Груп, 2015. 276 с.
 7. Tocco-Cano E., Paz Collado S., López-Gonzales J.L., TurpoChaparro J.E. A Systematic Review of the Application of Maturity Models in Universities. *Information*. 2020. Vol. 11, № 10. P. 466. DOI: [10.3390/info11100466](https://doi.org/10.3390/info11100466)
 8. Saxena A., Pant D., Saxena A., Patel C., Quiriello L. Emergence of Educators for Industry 5.0 - An Indological Perspective. *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*. 2020. Vol. 9, № 21. P. 359–363.
 9. Kadoić N., Đurek V., Dobrović Ž. Digital Maturity of Higher Education Institution: A Meta Model of the Analytical Network Process (ANP) and Decision Expert (DEX). *Central European Conference on Information and Intelligent Systems*. Varazdin, Croatia, 2018. P. 223–230.
 10. Bobro N. The concept of a digital university. *Наукові інновації та передові технології*, 2024, № 9 (37). P. 804-811. DOI: [https://doi.org/10.52058/2786-5274-2024-9\(37\)-804-811](https://doi.org/10.52058/2786-5274-2024-9(37)-804-811).
 11. Хоменко О. О., Паустовська М. В., Онищук І.А. Вплив інтерактивних технологій на процес навчання і розвиток здобувачів вищої освіти. *Наукові інновації та передові технології*. 2024. № 5(33). с. 1222-1231. DOI: [https://doi.org/10.52058/2786-5274-2024-5\(33\)-1222-1231](https://doi.org/10.52058/2786-5274-2024-5(33)-1222-1231).
 12. Гук П.В., Скляренко О.В. Економічна доцільність модернізації підприємств з використанням автоматизованих систем. *Економіка і управління*. 2022. № 2. с. 103-112. DOI: <https://doi.org/10.36919/2312-7812.2.2022.103>.
 13. Бобро, Н. Вплив на економічний розвиток цифрової трансформації університетів. *Сталий розвиток економіки*, 2024. № (3(50), с. 311-315. DOI: <https://doi.org/10.32782/2308-1988/2024-50-46>.