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DIGITAL DETERMINANTS OF EDUCATIONAL VALORISATION

The relevance of this study is driven by a shift in contemporary scholarly focus from the analysis of education digitalization technologies to the identification of their key driving forces–namely, digital determinants that define the direction, scale, and depth of the transformation of educational systems. These determinants create the preconditions for scaling the value of educational outcomes for individuals, society, and the economy in the digital era, while also highlighting the need to bridge the gap between the technological potential of digital change and its actual implementation and valorization in practice. In this context, there is a need to substantiate the theoretical and applied foundations of the valorization of the educational environment under conditions of digital transformation. The article confirms the hypothesis that the

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ЦИФРОВІ ДЕТЕРМІНАНТИ ВАЛОРИЗАЦІЇ ОСВІТИ

Актуальність дослідження зумовлена зміщенням сучасного наукового фокусу від аналізу технологій цифровізації освіти до виявлення її ключових рушійних сил – цифрових детермінант, які визначають вектор, масштаби та глибину трансформації освітніх систем. Саме такі детермінанти формують передумови до масштабування цінності освітніх результатів для особистості, суспільства та економіки в цифрову епоху, а також актуалізують потребу подолання розриву між технологічним потенціалом цифрових змін і реальною практикою їх використання та валоризації. У зв'язку з цим постає необхідність обґрунтування теоретичних і прикладних засад валоризації освітнього середовища в умовах цифрової трансформації. Висунуто гіпотезу, що цифрова трансформація

digital transformation of education contributes to the creation of additional social and economic value of educational outcomes, while the valorization of the educational environment serves as a key instrument for enhancing the competitiveness of education, fostering digital human capital, and integrating education into the digital economy. The methodological framework of the study is based on systemic, structural-logical, and comparative approaches, as well as methods of generalization, comparative analysis, structural modelling, conceptual design, and the algorithmization of processes for assessing the valorization of the educational environment. The empirical basis of the study comprises statistical data from the European Commission, OECD, UNESCO, and Eurostat, as well as the results of a bibliometric analysis of research on the digital determinants of education from scientometric databases. The article identifies international and national trends in the digital transformation of education, highlights strategic directions for the development of the population's digital competences, and outlines key challenges facing digital education in the context of the emerging knowledge economy. The level of digital education development in Ukraine is analyzed, along with the impact of digital technologies on the formation of digital competences and the development of human capital. A conceptual framework for the valorization of the educational environment under conditions of digital transformation is substantiated. Within this framework, the main effects of valorization are identified, a system of evaluation criteria is developed, and an algorithm for determining the levels of educational environment valorization is proposed. The framework makes it possible to assess the process of creating additional social, economic and innovative value of educational outcomes and can be used for the strategic planning of the transformation of educational systems and processes at institutional, regional, and national levels.

Keywords: digitalization, valorization, digital transformation, digital technologies, digital determinants, education, educational environment, competences, innovations, values, management.

освіти сприяє формуванню доданої соціально-економічної цінності освітніх результатів, а валоризація освітнього середовища є ключовим інструментом підвищення конкурентоспроможності освіти, розвитку цифрового людського капіталу та інтеграції освіти в цифрову економіку. Методологічну основу дослідження становлять системний, структурно-логічний і компаративний підходи, методи узагальнення, порівняльного аналізу, структурного моделювання, концептуального проєктування та алгоритмізації процесів оцінювання валоризації освітнього середовища. Емпіричну базу дослідження становлять статистичні дані Європейської Комісії, OECD, UNESCO, Eurostat, а також результати бібліометричного аналізу досліджень цифрових детермінант освіти, представлених у наукометричних базах даних. Розкрито міжнародні та національні тенденції цифрової трансформації освіти, висвітлено стратегічні напрями розвитку цифрових компетентностей населення та визначено ключові виклики розвитку цифрової освіти в умовах становлення економіки знань. Проаналізовано рівень розвитку цифрової освіти в Україні, а також вплив цифрових технологій на формування цифрових компетентностей і розвиток людського капіталу. Обґрунтовано концептуальний фрейм валоризації освітнього середовища в умовах цифрової трансформації, у межах якого визначено основні ефекти валоризації, сформовано систему критеріїв оцінювання та розроблено алгоритм визначення рівнів валоризації освітнього середовища. Запропонований фрейм дає змогу оцінювати процес створення доданої соціально-економічної та інноваційної цінності освітніх результатів і може бути використаний для стратегічного планування трансформації освітніх систем і процесів на інституційному, регіональному та державному рівнях.

Ключові слова: цифровізація, валоризація, цифрова трансформація, цифрові технології, цифрові детермінанти, освіта, освітнє середовище, компетентності, інновації, цінності, менеджмент.

JEL Classification: I 20, I 28, D 83, O 33, L 86.

Introduction

Digital technologies serve as a key driver of the transformation of modern society, reshaping approaches to education, professional activity, social and economic development, the formation of competitive human capital, and the achievement of sustainable economic growth. In the context of the emergence of a new vector of economic development based on the Society 5.0 paradigm (Mazaraki et al., 2020), the digital transformation of

education acquires strategic importance as the foundation for the implementtation of a knowledge-based economy and the enhancement of national competitiveness.

In this context, the European Union identifies the digital transformation of education as one of the priority areas of development within the Digital Decade 2030 initiative, according to which at least 80% of the population should possess basic digital skills by 2030 (European Commission, 2024, April 29). This initiative emphasizes the importance of developing digital competencies as a key factor in shaping digital human capital and ensuring sustainable, innovative economic growth.

According to Eurostat analytical findings, in 2024–2025, only 56–60% of the population of the European Union possess basic digital competencies, indicating the need to intensify the processes of digitalization in education and the development of digital skills among the population (Eurostat, 2025). At the same time, there is significant differentiation among EU countries. The highest indicators are demonstrated by the Netherlands, Finland, Denmark, and Ireland, where the level of digital skills exceeds 70–80%. The group of countries with a high level of digital competencies also includes Sweden, Luxembourg, Germany, and France, where the share of the population with basic digital skills exceeds 65–75%.

Countries of Southern and Central-Eastern Europe show average indicators, including Italy, Portugal, the Czech Republic, and Slovakia, where the level of digital skills ranges between 50–60%. The lowest indicators are characteristic of Romania, Bulgaria, Greece, and Poland, where the share of the population with basic digital competencies remains significantly below the European average (Eurostat, 2025), indicating the unevenness of the digital transformation of educational systems within the European Union (*Figure 1*).

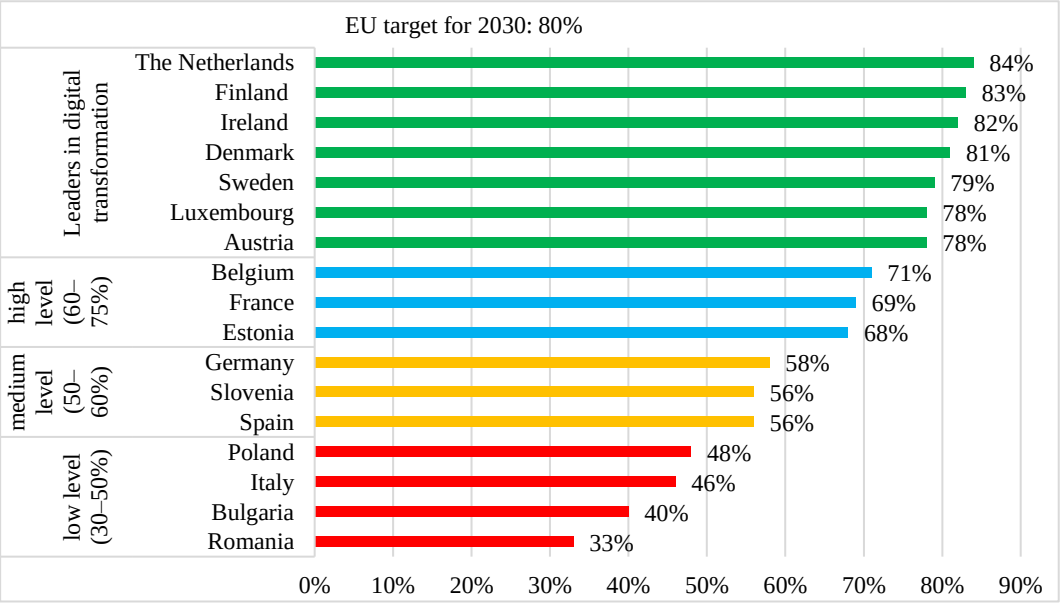

Figure 1. Level of basic digital competencies in EU countries, 2024–2025.

Source: compiled by the authors based on (European Commission, 2025, June 16; Eurostat, 2025).

According to the data presented in Figure 1, the level of digital competencies among the population of European Union countries is characterized by significant variation, indicating the uneven nature of the digital transformation of education across EU countries and highlighting the need to develop effective educational strategies to enhance digital competencies among the population (European Commission, June 16, 2025; Eurostat, 2025).

The key EU strategic document outlining the directions for the development of digital education is the Digital Education Action Plan 2021–2027, which identifies two main priorities: the development of a high-performing digital education ecosystem and the enhancement of digital competencies (European Commission, 2020). The Action Plan reflects the systemic nature of the digital transformation of education and emphasizes the development of digital competencies as an essential component of human capital.

Contemporary research confirms that the digitalization of education is accompanied by the active implementation of new technologies, including artificial intelligence, adaptive learning, digital platforms, and educational data analytics. Studies by the Organization for Economic Co-operation and Development (OECD) highlight that digital technologies contribute to the personalization of learning and improve the efficiency of the educational process; however, their implementation requires an adequate level of digital competencies among educators, as well as the development of digital infrastructure (OECD, January 19, 2026).

According to the position of the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the use of artificial intelligence in education creates new opportunities for individualized learning but also generates risks of digital inequality and underscores the need to establish ethical principles for the use of digital technologies (UNESCO, 2023).

International experience demonstrates the emergence of various models of digital transformation in education, depending on the level of countries' digital development and the strategic priorities of educational policy. Estonia integrates digital technologies and artificial intelligence into its education system, contributing to the development of a digital educational ecosystem and the enhancement of learners' digital competencies (European Commission, June 16, 2025).

Finland implements a comprehensive policy for the development of lifelong digital literacy, which involves integrating digital competencies at all levels of education (European Union, June 30, 2025). The Netherlands actively deploys digital educational platforms, adaptive learning technologies, and tools for personalizing the educational process, which enhances learning effectiveness and fosters the development of a digital educational environment (European Commission, August 7, 2024).

The generalization of international experience in the digitalization of education provides an analytical basis for assessing the level of digital education development in Ukraine, where the issue of digital transformation of the

educational environment is becoming increasingly relevant in the context of economic digitalization, integration into the European educational space, and the development of digital competencies of human capital.

Conditions of distance and blended learning further intensify the need to implement digital platforms, online courses, and digital educational technologies. In particular, the development of the Diia.Osvita platform is aimed at fostering digital competencies among the population and supporting the concept of lifelong learning (Diia.Osvita. Research, n. d.).

At the same time, alongside the study of international experience in the digitalization of education, it is important to generalize scientific research in this field. A critical analysis of the scientific literature indicates a growing scholarly interest in the digital transformation of educational systems, the development of digital competencies, and the implementation of innovative educational technologies. Considerable attention in contemporary research is paid to the formation of digital competencies as a key factor in the development of digital education.

In particular, the issue of developing educators' digital competencies has been examined in the works of Redecker (2017), which substantiates the European framework for the digital competence of educators, DigCompEdu. Carretero et al. (2017) developed the DigComp 2.1 framework for citizens' digital competence. The further development of this concept is presented in the study by Vuorikari et al. (2022), which identifies new digital competencies related to the use of artificial intelligence and modern digital technologies.

A significant contribution to the study of the digital transformation of education was made by Selwyn (2016), who considers the digitalization of education as a complex socio-economic transformation, as well as by Bond et al. (2020), who identified key trends in the use of digital technologies in higher education. The conceptual foundations of blended learning and digital educational environments are substantiated in the works of Garrison and Vaughan (2008), where the authors examine blended learning as an effective tool for the digitalization of the educational process.

A separate strand of research focuses on the implementation of artificial intelligence in education. In particular, Holmes et al. (2019) identify artificial intelligence as a key factor in the personalization of learning, while Zawacki-Richter et al. (2019) conducted a systematic analysis of AI applications in higher education and identified (promising) directions for its use.

The issue of the digitalization of education is also actively explored by Ukrainian scholars. Its current trends, including the development of lifelong learning technologies, open online courses, adaptive learning, distance education, gamification, and the use of virtual and augmented reality technologies, are examined in the works of Mala (2022) and Safonov and Korotun (2024). The problem of digitalization of education as a vector for training 21st-century specialists was studied by Demianchuk and Bodnaruk (2022), who emphasize the need for digital transformation of the educational process.

Zabiaka (2024) analyzed the digitalization of higher education in the European context, emphasizing expanded access to educational resources, flexibility of the learning process, and the implementation of the concept of lifelong learning. A significant contribution to the digital transformation of education in Ukraine has also been made by Bykov and Burov (2020), Shyshkina and Nosenko (2023), and Lukianova and Hodlevska (2024), who investigate the development of the digital educational environment, the formation of digital culture among participants in the educational process, and the implementation of information and communication technologies in education.

Certain aspects of the digitalization of the educational process in higher education are also presented in the works of Zabiyaka (2024), Kremen and Spirina (2024), Morze et al. (2023), and Nosovets et al. (2024), where the authors substantiate the use of digital educational platforms, distance learning, and blended learning as key tools for the modernization of education.

Research on digital competencies in the context of the digital economy is also presented in the works of Karpenko et al. (2025) and Zakharchenko and Makletskyi (2024), which confirm the hypothesis that digital competencies constitute an important component of the professional training of modern specialists in the context of the digital transformation of society.

A bibliometric analysis of scientific research indicates a high level of scholarly interest in the digitalization of education at both the international and national levels (*Table 1*).

Table 1

Bibliometric profile of digital determinants of education valorization (2015–2025)

Thematic area	Information base	Number of publications	Growth rate	Leading countries
Education management	Scopus / WoS	41 500	32%	Spain, USA, China, United Kingdom, India, Germany
Digital technologies in education		1 709	35%	
Artificial intelligence in education		3 623	67 times	
Digital competencies	WoS / Lens	1 797	6.5%	
Virtual reality in education	Scopus / WoS	1 157	5 times	
Digital transformation of education		5 506	50 times	
Valorization of education		12	–	
Knowledge valorization		51	–	

Source: compiled by the authors based on (Elsevier, n. d., Clarivate, n. d.; The Lens, October 24, 2022; The Lens, n. d.).

At the same time, in contemporary scientific discourse, the issues of creating added value within the educational environment under conditions of digital transformation remain insufficiently explored, which necessitates further research in the direction of educational environment valorization and the development of digital educational ecosystems.

The aim of this article is to substantiate the theoretical and applied foundations of education valorization in the context of digital transformation. To achieve this aim, the following objectives have been defined:

- to analyze the European experience of digital transformation of education and the development of digital competencies;
- to identify key trends in the development of Ukraine's digital ecosystem;
- to develop a conceptual framework of the determinants of educational environment valorization.

The study is based on the hypothesis that the digital transformation of education contributes to the creation of added social and economic value of educational outcomes, while the valorization of the educational environment serves as a key instrument for enhancing the competitiveness of education, fostering digital human capital, and acting as a prerequisite for the integration of education into the digital economy.

The research methodology is based on the use of systemic, structural-logical, and comparative analysis of international experience in the digitalization of education, statistical data from the European Commission, the Organization for Economic Co-operation and Development (OECD), the United Nations Educational, Scientific and Cultural Organization (UNESCO), Eurostat, as well as findings from contemporary scientific research in the field of digital transformation of education. The study employs methods of generalization, comparative analysis, structural modeling, conceptual design, and the algorithmization of processes for assessing the valorization of the educational environment.

Structurally, the article consists of three sections. The first section reveals European trends in the digital transformation of education, highlights the strategic directions for the development of digital competencies among the population, and identifies the key challenges in the development of digital education in the context of the emerging knowledge economy.

The second section is devoted to analyzing the level of development of digital education in Ukraine, examining the impact of digital technologies on the formation of digital competencies and the development of human capital.

The third section substantiates a conceptual framework for the valorization of the educational environment in the context of digital transformation. Within this framework, the effects of valorization are identified, a system of evaluation criteria is developed, and an algorithm for determining the levels of valorization of the educational environment is proposed. This makes it possible to assess the creation of added social, economic, and innovative value of educational outcomes.

1. European trends in the digital transformation of education

The digitalization of education is one of the key directions of educational policy in the European Union, aimed at developing digital competencies, modernizing the educational environment, and enhancing the competitiveness of human capital. In this context, the Digital Education Action Plan 2021–2027 plays an important role. The main objective of this initiative is to create a high-

performing digital education ecosystem and to improve the level of digital competencies among the population in order to adapt the education systems of member states to the conditions of digital transformation.

A critical analysis of its content has led to the following conclusions:

- the document outlines a long-term vision for the development of high-quality, inclusive, and accessible digital education;
- it emphasizes the need for the development of individuals' digital competencies throughout their lives;
- it identifies two key strategic directions for the digital transformation of educational activities: the development of a high-performing digital education ecosystem and the improvement of digital skills and competencies.

The first direction involves the development of digital infrastructure, the implementation of modern educational platforms, the creation of digital educational resources, and the training of teaching staff in the use of digital technologies. The second direction focuses on the development of digital competencies among learners, educators, and the broader population, in line with the concept of lifelong learning.

The implementation of these strategic priorities of digital education is actively carried out in European Union countries through national strategies for the digitalization of education, the development of digital infrastructure, and the enhancement of digital competencies among the population. Almost all EU member states have developed their own strategies for the digital transformation of education in accordance with the Digital Education Action Plan (2021–2027), which indicates the systemic nature of the transformation of the educational environment in Europe (European Commission, 2020). *Table 2* presents the results of a comparative analysis of the development of digital education in European Union countries, aimed at assessing the level of development of digital educational infrastructure, the formation of digital competencies among the population, and the degree of integration of innovative technologies into the educational process.

Table 2

A comparative analysis of the development of digital education in selected EU countries as of 2024–2025

Country	Digital education indicator	Analytical characteristics	Strategic impact
Finland	Digital skills of the population	About 82% of the population has at least basic digital skills; the country is distinguished by a high culture of lifelong learning	Indicates the effectiveness of the digital competence development policy and the strong integration of digital education into the lifelong learning system
	Educational ecosystem	The state policy of digitalization of education until 2027 is focused on the development of digital infrastructure, platforms and digital readiness of educational institutions	Forms a sustainable digital educational ecosystem, where digital technologies are not an auxiliary, but a system-forming element of learning
Estonia	Basic digital skills	62.6% of the population has at least basic digital skills, which is above the EU average; the share of ICT specialists in employment is 6.7%	Confirms the combination of general digital literacy with a strong human resource potential to support the digitalization of education
	Integration of AI and digital technologies	In 2024, the use of AI by businesses increased from 5.19% to 13.89%, and 52.6% of enterprises use cloud technologies, which is significantly higher than the EU average	The high digital maturity of the economy creates a favorable environment for the implementation of AI solutions and digital platforms in education

End of Table 2

Country	Digital education indicator	Analytical characteristics	Strategic impact
Nether-lands	National digital policy	The country remains one of the leaders in digital innovation, but faces a shortage of ICT personnel and a decrease in public investment in digital education. The roadmap includes 59 measures with a budget of 5.25 billion	The combination of strong scientific and technological potential with human resource constraints indicates the need to increase investments in digital competences and educational infrastructure
	Digital infrastructure	The Netherlands is among the leading EU countries in terms of digital connectivity and has a strategic goal to maintain its position as a European digital leader	Developed infrastructure creates the prerequisites for the large-scale use of digital educational platforms, adaptive learning and cloud services
Denmark	Position in the european digital transformation	Denmark is among the leading countries in the Digital Decade / DESI monitoring of digital maturity indicators	This indicates a systemic combination of digital infrastructure, skills and institutional capacity, which also has a positive impact on the education sector
Ireland	Digital environment and infrastructure	Ireland is among the countries with a high level of basic digital skills in the European dimension; the national digital development policy is coordinated by state bodies responsible for the digital economy and communications	A high level of digital integration of society supports the development of digital education and lifelong learning
Germany	Institutional conditions for digitalization	Germany is implementing large-scale digital transformation programs, and the European-wide Digital Decade monitoring records its participation in the systematic development of digital indicators	For the education sector, this means a gradual strengthening of digital infrastructure, platform solutions and digital training, although the pace of transformation is more institutionally complex than in Scandinavian countries
EU as a whole	Strategic framework	The Digital Education Action Plan 2021–2027 identifies two key areas: the development of a highly effective digital education ecosystem and the improvement of digital skills and competences	These areas are the basis for a comparative assessment of national models of digitalization of education and identification of strengths and weaknesses of countries

Source: compiled by the authors based on (European Commission, 2020; European Commission, August 7, 2024).

As shown in *Table 2*, Finland demonstrates one of the most successful examples of implementing the strategic direction of developing a high-performing digital education ecosystem. Within the framework of the national policy of education digitalization, the country develops digital infrastructure, educational platforms, and distance learning formats. A high level of digital preparedness among educators and learners has ensured the stability of the educational process in the context of digital transformation (Digital Skills and Jobs Platform, 2025).

Estonia is one of the leaders in the digitalization of education in Europe. The country actively implements digital educational platforms, electronic textbooks, and digital learning management services. Moreover, within the framework of the national initiative (AI Leap, n. d.), the integration of artificial intelligence into the educational process is envisioned, which contributes to the development of digital competencies among both learners and educators.

In Denmark, the digitalization of education is carried out through the development of digital platforms, open educational resources, and digital learning tools. According to the Digital Economy and Society Index (DESI) report, Denmark is among the leading countries in terms of the level of digital competencies of its population and the development of digital education (European Commission, August 7, 2024).

In the Netherlands, the digital transformation of education involves the active use of digital educational platforms, adaptive learning, and artificial intelligence. Research by the Organization for Economic Co-operation and Development (OECD) indicates that the digitalization of education is a key direction in the development of the country's education system, with digital technologies being integrated into the learning process (OECD, 2023).

Germany implements the digital transformation of education through the national program DigitalPakt Schule, which predicts the development of digital infrastructure in educational institutions, the implementation of digital platforms, and the enhancement of digital competencies among educators and learners (Federal Ministry of Education and Research, n. d.).

Ireland actively introduces digital educational technologies within the framework of the national Digital Strategy for Schools, which includes the use of digital resources, the development of digital competencies, and the integration of digital technologies into the learning process (Department of Education Ireland, 2021).

A comparative analysis of the development of digital education in EU countries indicates the systemic nature of the digital transformation of the educational environment and the active implementation of innovative technologies in the learning process. The highest level of digital education development is demonstrated by the countries of Northern Europe, particularly Finland, Denmark, and Estonia, which are characterized by a high level of digital competencies among the population, well-developed digital infrastructure, and the active use of artificial intelligence in education.

At the same time, Western European countries, including the Netherlands, Germany, and Ireland, demonstrate a systematic approach to the digitalization of education through government programs, institutional mechanisms, and the development of digital educational platforms.

The successful digital transformation of education requires significant investments in the development of digital infrastructure, educational technologies, and digital competencies of the population. In this context, financial instruments of the European Union play an important role in supporting the digitalization of education and the development of digital skills. In particular, the Digital Europe Programme *2021–2027* provides funding of EUR 7.5 billion, a substantial portion of which is allocated to the development of digital competencies, artificial intelligence, digital infrastructure, and educational technologies (European Commission, April 29, 2024).

Through the Recovery and Resilience Facility, EU countries attract significant investments in the digitalization of education. In particular, Germany invests more than EUR 6.5 billion in the *DigitalPakt Schule* program, France allocates more than EUR 3 billion for the digital transformation of education, Italy invests over EUR 2.1 billion, and Spain invests more than EUR 1.4 billion in the development of digital educational platforms and population digital competencies (EUR-Lex, September 28, 2021).

Thus, financial support for the digitalization of education in EU countries is an inherent condition of its digital transformation. It has a comprehensive character and encompasses the development of digital infrastructure, educational technologies, and digital competencies of the population.

To generalize the financial instruments supporting the digital transformation of education in EU countries, key funding areas and investment volumes have been systematized and are presented in *Table 3*.

Table 3

Funding for the digital transformation of education in EU countries

Country	Programme	Funding amount, EUR billion	Investment areas
EU	Digital Europe Programme 2021–2027	7.5	AI, digital competences, digital infrastructure, educational technologies
Germany	DigitalPakt Schule	6.5	Digitalization of schools, infrastructure, digital platforms
France	Recovery and Resilience Facility	3	Digitalization of education, digital competences
Italy		2.1	Digital educational platforms
Spain		1.4	Digital competences and digital education

Source: compiled by the authors based on (EUR-Lex, September 28, 2021; European Commission, April 29, 2024).

The analysis of funding volumes indicates substantial investments by EU countries in the development of digital education. The largest financial resources are directed toward the modernization of digital infrastructure, the development of digital competencies among the population, and the implementation of innovative educational technologies. This confirms the strategic role of digital education as a key factor in the development of human capital and the establishment of a digital economy.

An important analytical tool for assessing the level of digitalization of education is the Digital Economy and Society Index (DESI), which is used to monitor the development of digital competencies, the state of digital infrastructure, and the level of integration of digital technologies into society. This index makes it possible to conduct a comparative analysis of the digital maturity of European Union countries and to identify leaders in the digital transformation of the educational environment.

According to recent studies, the group of leading countries in digital education based on the DESI includes the Netherlands, Finland, Denmark,

Sweden, and Ireland, which demonstrate a high level of digital competencies among the population and the active implementation of digital educational technologies (*Table 4*).

Table 4

Trends in the development of digital competencies in leading EU countries according to the DESI index

Country	Share of population with basic digital skills, %			Analytical characteristics
	2022	2023	2024	
Netherlands	80.5	82.1	82.7	One of the leaders in digital competencies in the EU
Finland	79.0	81.0	82.0	Stable high level of digital literacy
Denmark	67.0	68.8	69.6	Systematic state policy of digitalization
Ireland	70.0	72.1	73.0	Active development of the digital economy
Sweden	68.0	70.5	72.0	High level of digital education
EU (medium)	54.0	55.6	56.0	Moderate growth dynamics

Source: Compiled by the authors based on data from (European Commission, September 23, 2023; European Commission, April 29, 2024; Eurostat, 2025).

The obtained results indicate that the digitalization of education in the European Union is a priority strategic objective, characterized by a systemic nature and based on the integration of public policy, investment in digital infrastructure, continuous development of digital competencies, the use of artificial intelligence technologies, and the implementation of innovative educational technologies and digital educational platforms.

At the same time, the results of the comparative analysis demonstrate the uneven development of digital education across countries and the existence of different models of its implementation depending on the level of digital maturity of national education systems.

The level of a country's economic development is determined by the combined effect of two key factors: the quality of the national education system and the depth of the digital transformation of the economy. Education ensures the formation of human capital necessary for innovation and increased labor productivity, while digitalization contributes to the optimization of production processes, the reduction of transaction costs, and the acceleration of knowledge exchange.

Thus, countries with more advanced educational institutions and broader implementation of digital technologies demonstrate sustainable GDP growth and competitiveness in global markets. In the context of studying the digital transformation of the educational environment in Ukraine, it is advisable to conduct an analysis of the development of digital education in Ukraine, taking into account existing challenges and opportunities.

2. Analysis of the development of digital education in Ukraine

The diagnosis of the problems in the development of digital education in Ukraine makes it possible to assess the level of digital transformation of the educational environment, the formation of digital competencies among the population, and the potential for adapting international experience to the national education system.

The development of digital education in Ukraine is taking place in the context of an active digital transformation of society, accompanied by expanded access to the Internet, the development of digital competencies among the population, the growth of the EdTech sector, and the implementation of digital educational technologies. The increasing number of digital educational initiatives contributes to the formation of a national digital education ecosystem, which includes educational platforms, digital educational resources, and innovative learning technologies (Sigma Software University, October 7, 2024).

The analysis of the development of digital education in Ukraine is carried out in stages, allowing for a comprehensive assessment of the key directions of the digital transformation of the educational environment. At the first stage, the development of Ukraine's EdTech ecosystem and digital educational platforms is examined. The second stage involves assessing the level of digital competencies among the population of Ukraine. The third stage focuses on analyzing the dynamics of digital skills over time. The fourth stage is devoted to examining the impact of the level of education on the formation of digital competencies. The fifth stage includes the study of digital competencies among youth as a key group in the formation of digital human capital. The sixth stage involves assessing the readiness of young people to use artificial intelligence technologies in the educational process.

Such a staged approach makes it possible to comprehensively study the development of digital education in Ukraine and to identify key trends in the formation of digital human capital in the context of digital transformation.

In accordance with the proposed research logic, the first stage involves analyzing the development of Ukraine's EdTech ecosystem. One of the key tools for such analysis is the EdTech Map, which is used to assess the development of digital educational platforms, innovative technologies, and educational startups. The results of the EdTech Map study indicate that online education in Ukraine is at a stage of active growth and structural transformation.

The online education ecosystem is represented by various segments of digital educational solutions, including distance schools, massive open online course (MOOC) platforms, tutoring services, professional skills development platforms, language-learning services, and learning management systems (LMS), as summarized in *Table 5.*

Table 5

Segment analysis of EdTech solutions for digital education in Ukraine

Digital Education Segment	Title of the institution/platform	Digital Solution Type	Functional purpose
Online and Distance Learning	All-Ukrainian lyceum YASNO	Distance education platform	External support and distance learning
International education	Education center "Optima"	Online school	Distance education
	EdEra	Educational digital platform	Online learning and educational services
Language learning	Optima School	Educational platform	Cambridge International Education programs
STEM education	TalkEn.Cloud	LMS platform	Online language learning
	Smarte / Class Builder	Digital content platform	Online textbooks
Educational management	GIOS	AI educational platform	Mathematics learning
	#brobots	STEM school	Technical education
Professional training	Voopty	ERP/CRM system	Educational business management
	TGI Academy	Educational management system	Educational process automation
Educational digital content	"Yedyna Shkola"	Educational ecosystem	Personalized learning
Tutoring	Sigma software university	Educational provider	Employee training
Digital education segment	AR Book	AR/VR Platform	Interactive learning
Online and distance learning	PROSTE ZNO	Educational platform	Preparation for national multi-subject test (NMT) / external independent evaluation (EIE)

Source: compiled by the authors based on (EdTech Ukraine Association, n. d.).

The results of the analysis of EdTech solutions presented in *Table 5* indicate the formation of a multi-component digital educational ecosystem in Ukraine, characterized by the active development of digital platforms, learning management systems, and innovative learning technologies. An important feature of the Ukrainian EdTech sector is the growing number of digital management solutions that automate educational processes, personalize learning, and improve the efficiency of educational activities.

A notable trend in the development of digital education is the spread of STEM platforms and artificial intelligence-based solutions, in particular GIOS and AR Book, which demonstrate the gradual integration of innovative technologies into Ukraine's digital education system (EdTech Ukraine Association, n. d.; GIOS, n. d.). At the same time, the development of platforms for professional training and exam preparation is shaping trends toward the implementation of lifelong learning and increasing demand for the development of digital competencies throughout life (IT Ukraine Association, n. d.; European Commission, 2020).

Thus, the dominant trends in the development of Ukraine's EdTech ecosystem are:

- institutionalization and a European integration orientation of long-term strategies for the digital transformation of education;
- investment planning through the digital ecosystem;
- development of digital literacy among the population and digital accessibility;
- diversification of digital educational solutions;
- development of online and distance learning;
- integration of artificial intelligence technologies into educational ecosystems;
- development of learning management systems;
- formation of digital platforms for lifelong learning;
- harmonization of educational processes with the European digital space;
- formation of a sectoral focus of digital innovation development (DefenseTech, MedTech, EdTech, Agritech, AI, eco-technologies, etc.);
- ensuring digital resilience and cybersecurity of the EdTech ecosystem.

These processes are taking place under martial law conditions, are systemic, and aim to ensure economic resilience and the country's post-war recovery.

The EdTech map demonstrates the territorial concentration of online education in Ukraine. The main centers of development of the EdTech ecosystem are Kyiv, Kharkiv, Lviv, Dnipro, and Odesa. The territorial distribution of EdTech organizations is presented in *Figure 2*.

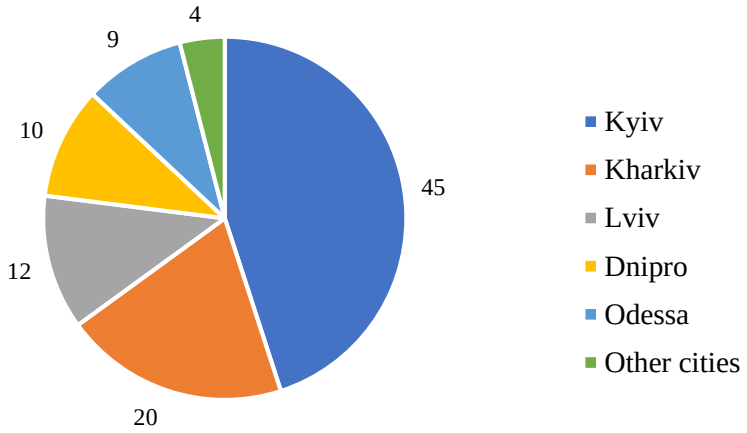

Figure 2. Geographical Distribution of EdTech Organizations in Ukraine, %

Source: Compiled by the authors based on (EdTech Ukraine Association, n. d.).

As shown in *Figure 2*, the largest number of EdTech organizations is concentrated in Kyiv, which can be explained by the high level of development of digital infrastructure, the concentration of IT companies, and educational institutions. At the same time, Kharkiv, Lviv, Dnipro, and Odesa

form regional centers for the development of digital education. This distribution confirms the cluster model of EdTech sector development, according to which more than 70% of online educational organizations are concentrated in the largest cities of Ukraine (EdTech Ukraine, n. d.).

Alongside the development of the EdTech ecosystem, an important factor in the digital transformation of education is the level of digital readiness of the population, which determines the effectiveness of the implementation of digital educational technologies and innovative platforms. In this context, it is appropriate to analyze the level of digital literacy of the Ukrainian population and the development of digital competencies.

According to the results of the 2025 study on digital literacy and artificial intelligence, the share of the adult population of Ukraine with access to the Internet has increased by 8% compared to 2019 and amounts to about 97%. This indicates a high rate of development of digital infrastructure and active digitalization of society (Ministry of Digital Transformation of Ukraine, n. d.).

The assessment of the level of digital competencies of the Ukrainian population was carried out in accordance with the European Digital Competence Framework (DigComp), which identifies four key groups of competencies: information skills, communication skills, problem-solving skills, and digital content creation skills (Redecker, 2017; Ministry of Digital Transformation of Ukraine, n. d.).

Based on these groups of competencies, levels of digital competencies among the population were determined, which made it possible to assess the degree of digital readiness of society for the implementation of digital educational technologies. A summary of the levels of digital competencies of the Ukrainian population in accordance with the DigComp methodology is presented in *Table 6*.

Table 6

Levels of digital competencies* among the Ukrainian population (according to the DigComp methodology)

Level of digital competences	Level characteristics	Description of skills development
None	Lack of digital skills	No digital skills in all four competency groups, and/or the person has not used the Internet in the last three months
Low	Partial development of digital skills	Some digital skills are available, but there are no competencies in at least one of the key areas
Basic	Development of basic digital skills	The level of digital skills in all four competency groups is not lower than basic
Above basic	High level of digital competences	The level of digital skills in all four competency groups is above basic, with active use of digital technologies

** The key groups of digital competencies according to the DigComp framework include: information literacy, communication and collaboration, digital content creation, safety, and problem-solving.*

Source: compiled by the authors based on (European Commission, 2017; Eurostat, 2025).

The analysis of the levels of digital competencies of the population presented in *Table 5* indicates a differentiated nature of digital skills development and demonstrates varying levels of digital readiness among the population to use modern educational technologies.

The application of the DigComp methodology:

- ensures a comprehensive assessment of digital competencies across key areas, including information literacy, communication skills, problem-solving, and digital content creation;
- makes it possible to determine the degree of digital integration of the population into the modern information environment and to assess readiness to use digital educational platforms.

Of particular importance is the transition of the population from a basic level to an above-basic level, which indicates the formation of digital human capital and an increase in the efficiency of the use of digital technologies in educational activities.

For a more in-depth analysis of the development of digital competencies, the dynamics of changes in the level of digital skills of the population of Ukraine have been studied. This approach made it possible to identify trends in the formation of digital literacy and to assess the level of readiness of the population to use digital educational technologies (*Figure 3*).

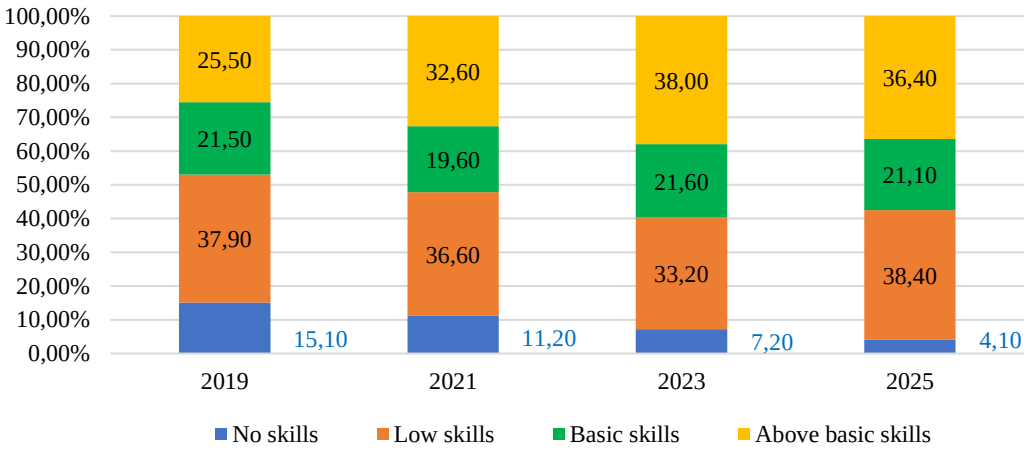

Figure 3. Trends in the level of digital skills among the Ukrainian population aged 18–70 in 2019–2025

Source: compiled by the authors based on (Ministry of Digital Transformation of Ukraine, n. d.).

According to the data presented in Figure 3, the share of the population without digital skills has significantly decreased over the studied period. At the same time, the proportion of the population with above-basic digital skills has increased, indicating a gradual improvement in the digital literacy of the Ukrainian population.

The share of the population with a low level of digital competencies remains relatively stable, which points to uneven digital development and the

need for further improvement of the digital education system with the differentiation of technologies for various population segments.

An important aspect of the study of digital competencies is their assessment depending on the level of education of the population, which makes it possible to determine the impact of educational factors on the formation of digital skills (*Figure 4*).

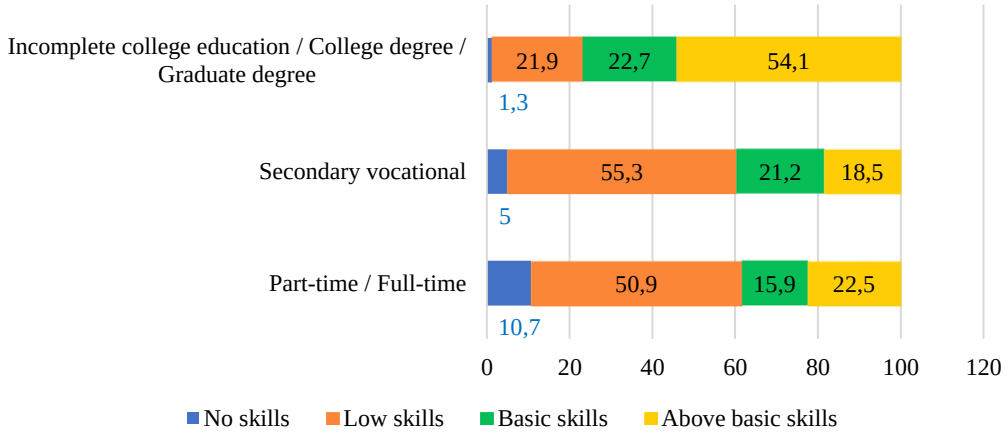

Figure 4. Digital competence levels of the Ukrainian population aged 18–70 by education level, 2025, %

Source: compiled by the authors based on (Ministry of Digital Transformation of Ukraine, n. d.).

The data presented in *Figure 4* indicate a pronounced differentiation in the digital competencies of Ukraine's population depending on the level of education. The most favorable profile of digital literacy is characteristic of individuals with higher education (academic degrees), confirming the importance of the educational environment as a factor in the accumulation and renewal of digital capital. In contrast, among groups with lower levels of formal education, there is a noticeable shift in the structure of digital skills toward basic and below-basic levels, which may limit the ability of these groups to fully participate in digitalized social and economic processes.

Particular attention should be paid to population groups with secondary and vocational secondary education, for whom an insufficient level of digital competencies necessary for the effective use of modern digital technologies in professional, educational, and everyday activities is typical. At the same time, the lower share of complete absence of digital skills among individuals with vocational secondary education may indicate a certain influence of professional training and practical experience on digital adaptation.

Thus, the level of education serves as one of the key determinants of digital literacy in the population. The identified differences highlight the need to develop targeted digital learning programs for groups at higher risk of digital vulnerability, particularly through instruments of non-formal education, short-term courses, micro-credentials, and practice-oriented digital training.

The obtained results confirm that the level of education is one of the key factors in shaping the digital competencies of the population and in the development of digital human capital.

Further analysis should be directed toward the study of digital competencies of youth as a key group in the formation of digital human capital and the development of the digital economy. In this context, particular interest lies in assessing the level of digital competencies of adolescents as the most active users of digital technologies (*Figure 5*).

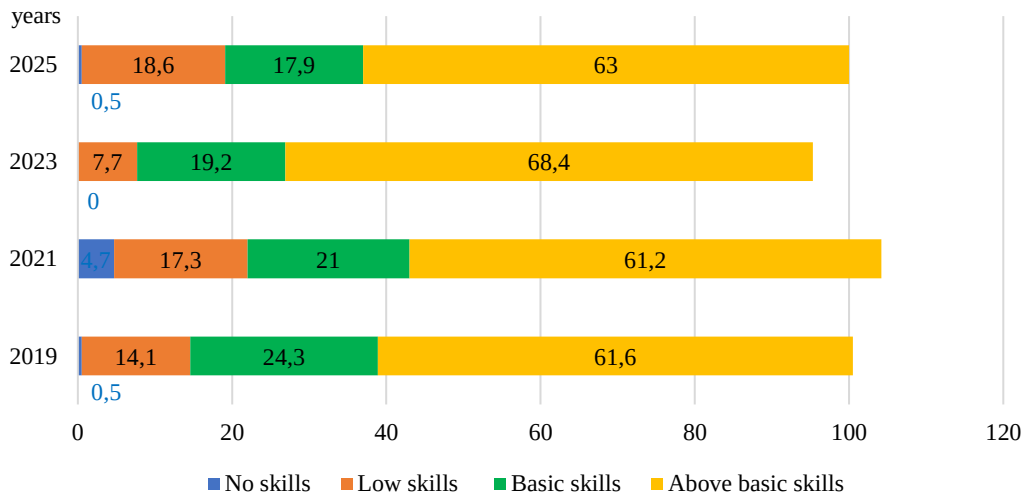

Figure 5. Digital skills of young people, 2019–2025, %

Source: compiled by the authors based on (Ministry of Digital Transformation of Ukraine, n. d.).

The analysis of the dynamics of adolescents' digital skills in 2019–2025 indicates the overall maintenance of a high level of digital competence within this age group. Throughout the study period, the share of adolescents with above-basic skills remained dominant, confirming their strong engagement in the digital environment and active use of digital technologies in learning, communication, and everyday activities. At the same time, the trends are not uniform. After reaching its highest value in 2023, the share of adolescents with above-basic skills declined, which may indicate a certain instability in maintaining a high level of digital competencies. A positive trend is the reduction in the share of adolescents with only basic digital skills, suggesting a gradual transition of part of the youth to more advanced forms of digital activity.

At the same time, the increase in the share of adolescents with low levels of digital skills in 2025 demonstrates the uneven nature of digital development within this age group. This may be associated not only with access to digital technologies, but also with differences in the quality of their use, educational support, motivation, and the nature of digital practices. The share of adolescents without digital skills remains negligible, confirming the nearly universal engagement of youth in the digital space.

Thus, adolescents remain one of the most digitally integrated groups in society. However, the observed fluctuations and the presence of a group with low skill levels highlight the need for targeted educational interventions aimed at developing critical, safe, and productive use of digital technologies, as well as the formation of digital human capital.

The high level of digital competencies among adolescents necessitates an analysis of their attitudes toward emerging digital technologies, particularly artificial intelligence, which is increasingly being integrated into the educational process. In this context, it is appropriate to examine adolescents' attitudes toward artificial intelligence technologies, the results of which are presented in *Figure 6*.

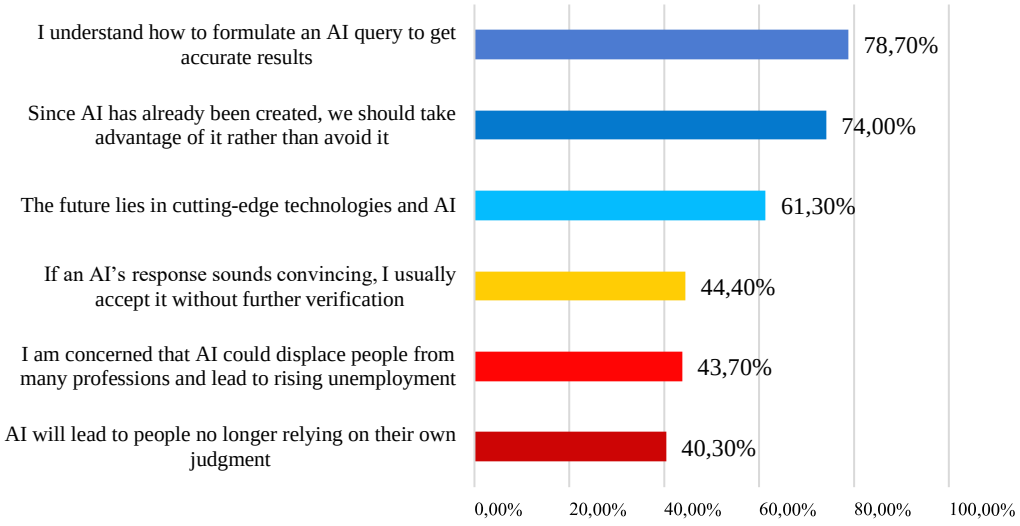

Figure 6. Adolescents' readiness to use artificial intelligence technologies

Source: compiled by the authors based on (Ministry of Digital Transformation of Ukraine, n. d.).

The obtained results indicate a high level of adolescents' digital adaptation to artificial intelligence technologies and highlight the need to develop skills for the critical use of digital resources within the educational process.

Overall, the results of the analysis of digital education development in Ukraine point to an active digital transformation of the educational environment, accompanied by the growth of the EdTech ecosystem, an increase in the population's digital competencies, and a rising level of digital integration among youth. The formation of digital human capital and the spread of AI technologies create the preconditions for rethinking the role of education in the modern digital economy, contribute to the transformation of the educational process, and enhance its economic and social value. This brings to the forefront the issue of valorization of education as a mechanism for improving its effectiveness, competitiveness, and alignment with the requirements of the digital economy.

Thus, the results of the conducted analysis confirm the active development of digital education in Ukraine, characterized by the formation of an EdTech ecosystem, the improvement of the population's digital competencies, and the increasing digital integration of youth. The digital transformation of education contributes to greater accessibility of educational resources, the emergence of new learning models, and the development of digital human capital, which, in turn, raises the importance of enhancing the social and economic value of education and the efficiency of utilizing educational outcomes.

3. Conceptual framework of determinants of the valorization of the educational environment

The digital transformation of education contributes to the growing importance of valorization of the educational environment as a mechanism for enhancing the social, economic, and innovative value of educational outcomes. In academic research, the valorization of education is understood as a process of creating added value from educational outcomes through their practical application and integration into social and economic development. The European Commission defines knowledge valorization as the process of generating social and economic value through the effective utilization of the results of education and research, emphasizing the role of education in fostering an innovation-driven economy (European Commission, April 23, 2026).

The theoretical foundation of this approach is the Triple Helix model, within which the valorization of education is considered through the interaction of universities, business, and government, ensuring the formation of an innovative educational environment and the development of a knowledge-based economy (Etzkowitz & Leydesdorff, 2000, pp. 111–115).

Benneworth and Arregui-Pabollet (2021) emphasize that the valorization of education involves the creation of social and economic value within the educational environment through the interaction of education, science, and the labor market, which contributes to improving the effectiveness of educational systems and the development of an innovation economy.

A critical reflection on contemporary scientific achievements allows for interpreting the valorization of the educational environment as a comprehensive process of creating the added value of education, shaped by digital transformation, the development of innovative technologies, and the strengthening of the interaction between education and the labor market. Based on the generalization of theoretical and methodological approaches, a framework of determinants of educational environment valorization has been substantiated, reflecting the structural elements, drivers, and mechanisms for generating added social, economic, and innovative value of education in the context of digital transformation (*Figure 7*).

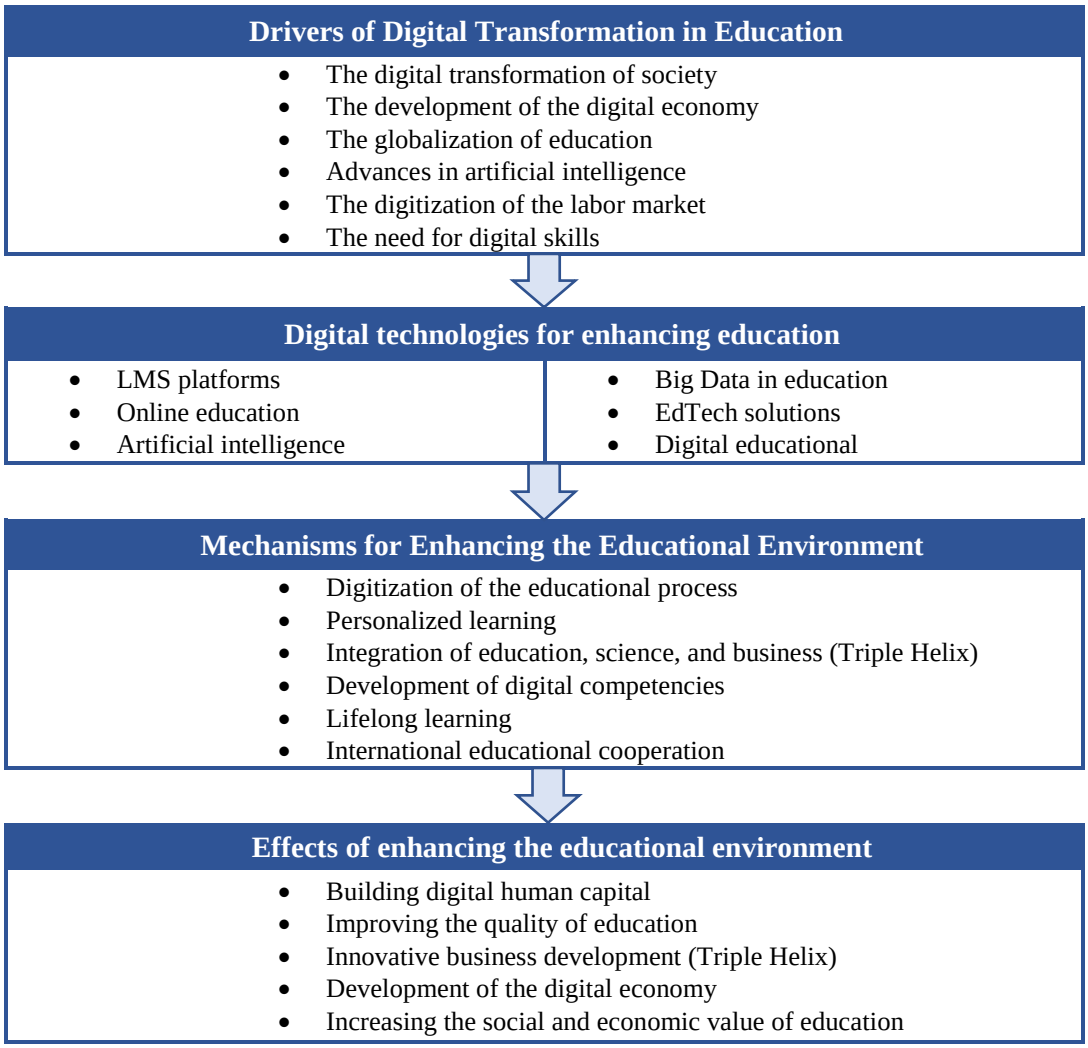

Figure 7. Conceptual framework of determinants of educational environment valorization

Source: compiled by the authors.

Within the conceptual framework proposed in *Figure 7*, the key effects of educational environment valorization are substantiated. For the purpose of their practical application, these effects have been operationalized through a system of characteristics and KPI-based evaluation indicators, as presented in *Table 7*.

Table 7

Effects of the valorization of the educational environment

Valorization effect	Characteristics	Manifestation in the digital educational environment	KPI evaluation
Improving the quality of education	Improving the educational process through digitalization	Development of digital competencies; modernization of educational programs	Level of digital competencies, level of academic success, and level of student satisfaction
Forming digital human capital	Developing digital skills and adaptability of education seekers	Development of digital skills; innovative thinking	Level of digital literacy; level of graduate employment

End of Table 7

Valorization effect	Characteristics	Manifestation in the digital educational environment	KPI evaluation
Increasing the competitiveness of education	Adapting educational programs to the needs of the labor market	Development of digital platforms; cooperation with employers	Share of employers; number of updated educational programs
Developing an innovative economy	Forming a knowledge economy	Development of EdTech; integration of education and business	Number of EdTech projects; level of innovative activity
Integration into the global educational space	International cooperation and digitalization of education	Online education; international platforms	Number of international projects; share of online courses

Source: compiled by the authors.

The presented effects of valorization of the educational environment and the corresponding KPIs enable a comprehensive assessment of the results of the digital transformation of education and help identify strategic directions for the development of the educational environment. The proposed approach provides an opportunity for both quantitative and qualitative evaluation of the level of educational valorization.

To determine the level of valorization of the educational environment, a system of evaluation criteria has been developed, based on educational, economic, innovative, and social indicators of the development of the educational environment (*Table 8*).

Table 8

Matrix of criteria for assessing the level of valorization of the educational environment

Evaluation criteria	Basic level	Digital level	Innovative level	Integration level	Strategic level
Educational	Fragmented digitalization of the educational process	Use of digital platforms and online courses	Personalized digital learning and adaptive technologies	Integration of digital technologies into all educational programs	Digital educational ecosystem and flexible educational models
Economic	Episodic interaction with employers	Initial integration with the labor market	Active cooperation with business and employers	System partnerships and joint educational programs	Strategic educational-business alliances and innovation ecosystems
Digital	Use of certain digital technologies	Implementation of digital educational tools	Use of EdTech and AI technologies	Formation of innovative educational ecosystems	Digital innovative ecosystem of education
Social	Limited availability of digital education	Expanding availability of digital learning	Formation of digital competencies of education seekers	Integration into the international educational space	Global integration of the educational environment

Source: compiled by the authors.

For a generalized quantitative assessment of the level of valorization of the educational environment, it is advisable to use an integral indicator (1), since the significance of individual groups of criteria is determined by the characteristics of a particular educational environment. This is determined by strategic priorities of the educational institution, its level of digital maturity, resource provision, the intensity of interaction with external stakeholders, and its orientation toward innovative development and social impact.

$$Vi = w_1O + w_2E + w_3D + w_4S \quad , \quad (1)$$

where: Vi – integral indicator of the valorization of the educational environment;
O – composite indicator of educational criteria;
E – composite indicator of economic criteria;
D – composite indicator of digital criteria;
S – composite indicator of social criteria.
w_1, w_2, w_3, w_4 – weighting coefficients of the respective groups of criteria, reflecting their relative significance within a particular educational environment.

Each composite indicator represents a generalized assessment of the corresponding block of criteria. Such a model ensures the adaptability of the evaluation and enhances its analytical sensitivity, as it takes into account the context in which the educational environment operates. Under certain conditions, digital criteria may be decisive, while in others, educational, economic, or social criteria may prevail. This approach is consistent with the practice of applying composite indices in the field of digital transformation and the assessment of complex systems development, including within the DESI framework, as well as with the use of SELFIE as a tool for self-assessment of the digital readiness of educational institutions.

The weighting coefficients may be determined based on expert evaluation, the pairwise comparison method, the analytic hierarchy process, or the empirical validation of the model within a specific educational institution. This ensures not only the formal aggregation of criteria but also the methodologically grounded construction of an integral indicator that is relevant to the actual conditions of the educational environment's functioning (Nardo et al., 2008).

The interpretation of the obtained value is advisable to carry out using a five-level scale of valorization: basic, digital, innovative, integrative, and strategic levels. The proposed indicator can be used not only to determine the current state of valorization but also for dynamic analysis of changes over time, comparison of educational institutions or educational programs, as well as for identifying strengths and problematic aspects of development across specific groups of criteria. In this context, the integral indicator of valorization should be considered as a tool for strategic management of the development of the educational environment in the conditions of digitalization and the emergence of the knowledge economy.

Conclusions

The digital transformation of education necessitates a rethinking of the role of the educational environment as a key factor in the formation of human capital and the development of the knowledge economy. Under these conditions, the valorization of the educational environment acquires strategic importance, as it ensures the creation of added social, economic, and innovative value of educational outcomes through the integration of education, science, business, and society. The conducted analysis of European experience in the digital transformation of education has shown that the development of digital competencies, the implementation of digital technologies, and the formation of digital educational ecosystems are key factors in enhancing the competitiveness of educational systems and the development of digital human capital.

The digital transformation of education in Ukraine is taking place in the context of integration into the European educational space and the active implementation of digital technologies in the educational process. Key challenges in the development of the digital educational environment – particularly the unevenness of digital infrastructure, the need to develop digital competencies among participants in the educational process, and the formation of digital educational ecosystems – necessitate the development of conceptual approaches to the valorization of the educational environment as a tool for increasing the effectiveness of the digital transformation of education.

The study confirmed the hypothesis that the digital transformation of education contributes to the creation of added social and economic value of educational outcomes, and that the valorization of the educational environment is a key instrument for enhancing the competitiveness of education, developing digital human capital, and integrating education into the digital economy.

The conceptual framework for the valorization of the educational environment integrates the key determinants of value creation in education – namely, the effects of valorization, the system of evaluation criteria, and the levels of educational environment valorization. The proposed framework ensures: first, a comprehensive assessment of the digitalization of education; second, the identification of strategic directions for the development of the educational environment in line with current trends in the development of digital competencies, the implementation of digital technologies, and the integration of education, science, and business; and third, the formation of digital educational ecosystems and the enhancement of the social and economic value of educational outcomes.

The use of the integral indicator of educational environment valorization provides the opportunity for quantitative assessment of the level of development of the educational environment, conducting comparative analysis, and monitoring the dynamics of changes. Such an approach makes it possible to identify the strengths and weaknesses of the development of the

educational environment, justify managerial decisions, and determine strategic directions for increasing the social, economic, and innovative value of educational outcomes based on strengthening the role of education as a strategic factor in the formation of digital human capital and the development of the knowledge economy.

The results of the study create a theoretical and methodological foundation for further research on the implementation of the concept of educational environment valorization in the activities of educational institutions and form a scientific and practical basis for the transformation of educational models, which will contribute to the training of competitive professionals, the development of digital human capital, and the enhancement of the adaptability of educational systems in the context of digital transformation.

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