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Digital transformation of the university educational environment: Pedagogical challenges and social consequences

Abstract. The study aimed to provide a comprehensive substantiation of the digital transformation of higher education. The methodology included an analysis of scholarly sources and strategic documents in the field of digital transformation in education, the conceptualisation of key concepts, a comparative analysis of traditional and digital learning models, and structural-functional modelling. The main findings of the study show that the digital transformation of education was systematically generalised as a multi-level process that simultaneously covers the pedagogical, technological and organisational dimensions of university functioning. The concept of the “digital educational environment of a university” was defined and conceptually clarified as an integrated ecosystem that includes digital platforms, educational content, communication channels, administrative systems and participants in the educational process who interact within a networked digital structure. The study established that digital transformation leads to a systemic change in the roles of participants in the educational process: the teacher is transformed from a transmitter of knowledge into a facilitator and designer of the learning environment, while the student acquires the status of an active agent and co-creator of knowledge. It was found that the key characteristics of the digital educational environment are interactivity, flexibility, accessibility, personalisation and technological mediation. The study demonstrates that digital educational technologies, including LMSs, online platforms, video communication and interactive tools, are becoming a central element in the organisation of the learning process. They support not only the transmission of knowledge, but also learning management, assessment, analytics of educational activity and the development of individual educational trajectories. A structural model of a university’s digital educational environment was also developed. It confirms that the effectiveness of the educational process depends on the integration of all components into a single digital system in which interaction between elements is continuous, adaptive and technologically mediated. The practical significance of the study findings lies in their potential use for designing and improving digital educational environments in higher education institutions, developing strategies for the implementation of blended and distance learning, and increasing the effectiveness of educational process management

Keywords: technological mediation; individual trajectories; administrative systems; blended learning; educational content

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INTRODUCTION

The digital transformation of universities is reshaping higher education by changing the organisation of the learning environment, the roles of teachers and students, and approaches to knowledge management. Digital technologies expand access to learning, support interactive and distance education, and strengthen student autonomy. At the same time, uneven digital development, insufficient digital competencies and organisational barriers create new challenges for universities. Therefore, research into the digital transformation of the university educational environment is relevant for improving the effectiveness, accessibility and quality of higher education.

In scholarly research, the digital transformation of the educational environment is considered a complex process that encompasses technological, organisational and pedagogical changes in the functioning of universities. The need to examine the impact of digitalisation on private universities provided the basis for empirical analysis. H.S. Majdi *et al.* (2024) investigated the impact of digital transformation on the educational environment of private universities. The authors analysed changes in the organisation of the educational process and emphasised the positive effect of digital technologies on educational effectiveness. They also noted the need to adapt management models to new conditions. These changes included the digitalisation of the educational process, the introduction of online and blended learning formats, the use of learning management systems (LMS), and expanded opportunities for personalising educational trajectories and automating assessment. A systematic review of scholarly publications makes it possible to summarise different approaches to the digital transformation of universities.

A. Fernández *et al.* (2023) conducted a multivocal literature review of digital transformation initiatives in higher education institutions. The authors analysed various models for implementing digital technologies and identified the key areas in the development of digital universities, including digital infrastructure, digital pedagogy, learning analytics and the integration of artificial intelligence into the educational process. The link between digitalisation and the sustainable development of education is addressed in studies of strategic change. L.V. Trevisan *et al.* (2024) examined digital transformation as a factor in sustainable development in higher education. They noted that digitalisation helps improve the efficiency of educational systems by making more effective use of resources, expanding access to highquality learning, reducing the costs of organising the educational process and increasing the adaptability of university systems to socio-economic change. The role of management practices and human capital in the digital transformation of education is also a subject of research.

A. Purwanto *et al.* (2023) analysed the impact of digital transformation and human resource management on university effectiveness. The authors found that the level

of digitalisation directly affects the performance of educational institutions by accelerating management processes, optimising resource use, automating assessment and improving access to educational materials. Barriers to the implementation of digital technologies in higher education form a separate area of research. T. Gkrimpizi *et al.* (2023) classified the main obstacles to the digital transformation of universities. The researchers identified infrastructural, organisational and cultural barriers that complicate the implementation of digital solutions. In practice, these barriers are reflected in inadequate digital infrastructure, fragmented management processes and resistance to change among teaching staff, which limits the effectiveness of assessment and makes equal student access to digital educational resources more difficult. Leadership and student engagement in the digital environment are also considered factors of effectiveness.

V. Niță & I. Guțu (2023) examined the role of leadership in digital transformation and its impact on student engagement. The authors emphasised the importance of management strategies in shaping the digital educational environment. In particular, their findings indicate that digital leadership strategies include proactive change management, support for a digital culture within the university, the development of digital competencies among teachers and students, and the creation of flexible models for managing the educational process, all of which increase student engagement and learning effectiveness. In an analytical review, U.V. Kiriyyenko (2023) conducted a comprehensive analysis of the state of digital transformation in the educational space. The author examined key trends in the digitalisation of education, presented specific cases of digital technology implementation in different countries and types of educational institutions, and focused on existing limitations and barriers, including infrastructural, staffing, methodological and psychological barriers. These key trends mark a transition towards hybrid and fully digital learning models, stronger personalisation of the educational process, the active introduction of data analytics and artificial intelligence into learning management, and the growing role of digital competencies as a basic condition for the effectiveness of contemporary education.

This study aimed to model the digital educational environment of a university in the context of a transition towards innovative, flexible and technologically mediated educational systems. The objectives of the study were to conduct a theoretical and methodological analysis of key concepts and scholarly sources related to the digital transformation of the university educational environment; to carry out a comparative analysis of traditional and digital models of organising the educational process; and to develop a theoretical model of the digital educational environment of a university, taking into account the interaction of its main elements and the transformation of the roles of participants in the educational process.

MATERIALS AND METHODS

The research design was based on a theoretical and analytical approach involving source systematisation, content analysis, comparative analysis and theoretical modelling of the digital educational environment of universities. A set of interrelated methods was used to study the digital transformation of the university educational environment, enabling a staged examination of changes in educational systems under the influence of digital technologies and artificial intelligence. At the first stage, the method of generalisation and systematisation of scholarly and regulatory sources was applied. To analyse the pedagogical challenges and social consequences of digital transformation, a qualitative analysis of scholarly publications and strategic documents was conducted. Scholarly sources were searched in the international databases Scopus, Web of Science, Google Scholar and OECD iLibrary to ensure the high academic validity of the materials. The main keywords were: “digital transformation of higher education”, “digital learning environment”, “educational technology”, “AI in education”, “digital competence of teachers”, and “pedagogical challenges of digitalization”. The study mainly used sources published between 2017 and 2025. These included scholarly sources, namely J. Hylen (2006), D.R. Garrison & N.D. Vaughan (2008), R. Eynon & L.-E. Malmberg (2021), O. Gherman *et al.* (2022), H. Crompton & D. Burke (2023), A. Allouche (2024). The study included studies by O. Kovalenko & I. Kutelmah (2025), N. Oliynyk *et al.* (2025), and S. Danylyuk (2025), which formed the empirical and theoretical basis for examining digital transformation in higher education. Sources published outside the 2017-2025 period were included in the analysis as foundational theoretical and methodological studies that are fundamental in nature and were used to develop the conceptual framework of the study.

International strategic and policy documents were examined, namely OECD (2023), the Rolling plan for ICT standardisation (2025), the Digital Education Action Plan (n.d.) and DigCompEdu (Punie & Redecker, 2017). Practical reports and analytical materials produced by international organisations were also analysed, including More than 48,000 Ukrainian teachers enrolled in UNESCO’s “digital teacher” training (2024), Latest report addresses digital transformation in blended learning environments (2024) and Digital education content: Guidelines for teachers and interoperability framework (2026). The sources were selected according to the following criteria: scholarly validity, meaning peer-reviewed publications or official publications of international organisations; thematic relevance, meaning a direct connection with the digital transformation of higher education; currency, with priority given to publications issued after 2017; and analytical depth. Using the method of systems analysis, the key structural components of the digital educational environment were identified, and their interrelations within an integrated educational system were determined. Aspects such as changes in the roles of participants in the educational

process, the technological mediation of learning, the personalisation of educational trajectories, the integration of artificial intelligence, and the infrastructural and organisational constraints of digital transformation were examined.

At the second stage, the method of abstraction was applied. This made it possible to move from the description of individual phenomena to the formation of generalised theoretical categories of digital education. Within this stage, the content of the key concepts was clarified: “digital transformation of education” was defined as a systemic change in the educational paradigm under the influence of technology; the “digital educational environment of a university” as an integrated ecosystem of interaction among students, teachers, platforms and resources; and “digital educational technologies” as a set of tools, including LMSs, online platforms and AI systems, that support the educational process. The key characteristics of the digital educational environment were also identified: interactivity, flexibility, accessibility, personalisation and technological mediation. To identify structural changes in the organisation of the educational process, a comparative analysis was conducted of the traditional, classroom-oriented learning model and the digital, technologically mediated learning model. The comparison of traditional and digital learning models was carried out according to the following criteria: the format of educational process organisation, the nature of pedagogical interaction, the distribution of the roles of teacher and student, the level of learner autonomy, the extent and functional role of digital technology use, the accessibility of learning materials, the pace of learning, approaches to assessment, the organisation of the educational process and the type of educational environment.

At the final stage, the method of theoretical modelling was used to construct a model of the digital educational environment of a university. The model includes such structural elements as the teacher, the student, digital platforms, including LMSs and educational services; educational content; communication channels; and administrative and analytical systems, all of which were derived from the analysis of the above-mentioned strategic documents. The model was analysed according to such criteria as the functional role of elements within the system, the nature of interaction between participants, the degree of technological mediation, changes in the roles of the teacher and the student, and the level of integration of digital technologies. The limitation of the study was that the analysis of the digital transformation of education was based mainly on theoretical and analytical sources, without extensive empirical measurement of practices in individual universities.

RESULTS

In the context of the development of the information society, higher education institutions are undergoing substantial transformations caused by the rapid introduction of digital technologies. Universities are gradually moving from traditional models of organising the educational

process towards digitally oriented educational environments that involve the use of online platforms, electronic resources and interactive learning tools. This transformation changes not only the instrumental basis of education, but also its content, teaching methods and the nature of interaction between participants in the educational

process. The digital educational environment of a university is regarded as an integrated socio-technical ecosystem that combines technological, pedagogical and organisational components. The digital transformation of education is accompanied by a range of pedagogical challenges and social consequences that require focused analysis.

Table 1. Pedagogical challenges and social consequences of the digital transformation of higher education

Category	Pedagogical challenges	Social consequences
Changing roles of participants	The teacher's transition from transmitter of knowledge to facilitator; the need for new competencies	Increased student autonomy; risk of loss of motivation among some learners
Technological mediation	Reduced quality of direct communication; screen fatigue	Increased social isolation and a widening digital divide among students
Personalisation and adaptability	Difficulty in creating individual trajectories; increased workload for teachers	Greater inequality in access to high-quality education
Integration of artificial intelligence as a component of the digital environment	The need to ensure the ethical use of AI, maintain academic integrity and develop students' critical attitude towards algorithms	Changing requirements for graduates' competencies and for the teacher's role in AI-supported learning
Infrastructural and organisational constraints	Insufficient interoperability of systems; data silos	Limited access to high-quality digital education in the regions

Source: compiled by the authors based on Digital Education Action Plan (n.d.), J. Hylen (2006), D.R. Garrison & N.D. Vaughan (2008), Y. Punie & C. Redecker (2017), R. Eynon & L.-E. Malmberg (2021), O. Gherman *et al.* (2022), OECD (2023), H. Crompton & D. Burke (2023), Latest report addresses digital transformation in blended learning environments (2024), More than 48,000 Ukrainian teachers enrolled in UNESCO's "digital teacher" training (2024), A. Allouche (2024), S. Danylyuk (2025), N. Oliynyk *et al.* (2025), O. Kovalenko & I. Kutelmah (2025), Rolling plan for ICT standardisation (2025)

The analysis of the data presented in the table shows that the digitalisation of higher education creates a complex balance between new opportunities and risks. The main pedagogical challenges remain the restructuring of the roles of participants in the educational process, ensuring the quality of interaction under conditions of high technological mediation, and the effective integration of artificial intelligence as a component of the digital educational environment. At the social level, the most pressing consequences are the risk of increasing educational inequality and the need to support participants in the educational process. These challenges can be addressed effectively only through the systematic integration of technological, pedagogical and organisational efforts.

OECD (2023) reports emphasise that digital technologies have transformed education and that the COVID-19 pandemic accelerated their integration into learning processes. At the same time, they stress that digitalisation should serve the goals of quality, equity and efficiency in education systems. The OECD also specifies the systemic nature of digital transformation by identifying the political, institutional and pedagogical dimensions of digital education, including infrastructure, governance, funding and the development of digital competencies. The European Union is developing an integrated digital education policy through the Digital Education Action Plan (n.d.), which sets strategic priorities for the development of digital skills, inclusive education and digital infrastructure. The plan also emphasises the need for cross-sectoral policy coordination (Rolling plan for ICT standardisation, 2025). An analysis of international approaches adopted by the OECD and the European Union shows

that the digital transformation of education is viewed as a multidimensional process that involves not only the introduction of technologies, but also systemic changes in governance, pedagogy and education policy. At the same time, emphasis is placed on the fact that the effectiveness of digitalisation is determined by its focus on quality assurance, equal access and the development of digital competencies, which makes it a key factor in the modernisation of contemporary education systems.

In addition, within this approach, the EU is developing practical tools for educators, including recommendations on the selection and use of digital content in teaching. These recommendations include criteria for quality, safety and pedagogical appropriateness (Digital education content..., 2026). The European Commission also emphasises the development of interoperability between educational systems, which is a necessary condition for forming a common European education area. Thus, international organisations view the digital transformation of education as a complex, multi-level process that includes not only technological infrastructure, but also pedagogical models, competency development and equal access. UNESCO policy represents a separate dimension of digital transformation, as it implements programmes to support teachers in the digital environment. In particular, the Digital Teacher programme is being implemented in Ukraine to develop teachers' digital competencies and support distance and blended learning. The programme has already reached more than 48,000 Ukrainian teachers, indicating a large-scale need for digital pedagogical transformation. In Ukraine, the digitalisation of education is taking place under martial law, which increases pressure on the

education system and accelerates the implementation of digital solutions (More than 48,000 Ukrainian..., 2024). Studies show that Ukrainian universities demonstrate adaptability to digital technologies, although they face infrastructural and staffing constraints (Danylyuk, 2025). An analysis of the transformation of language education in Ukraine within the DigiFLED project confirms that effective digitalisation is based on a combination of strategic management, digital pedagogical models, the development of LMS systems and the integration of artificial intelligence (Oliynyk *et al.*, 2025). Therefore, at the national level, the digitalisation of higher education in Ukraine combines global trends with local challenges caused by martial law and is characterised by the accelerated adaptation of universities to new conditions.

In the broader scholarly discourse, the digital transformation of education is viewed as a systemic restructuring of pedagogical models, involving a shift towards personalised, microlearning and AI-oriented approaches. Emphasis is placed on the formation of a new pedagogy based on creativity, humanism and meaning-making (Allouche, 2024). It is also stressed that digital technologies have become the main learning environment, which requires new teaching models and personalised educational trajectories (Gherman *et al.*, 2022). EU reports also state that the COVID-19 pandemic acted as a catalyst for the transition to digital and blended learning, while also revealing problems of unequal access, insufficient digital competency among teachers and the need for systematic investment in digital infrastructure (Latest report addresses digital transformation in blended learning environments, 2024). In Ukraine, UNESCO initiatives aimed at supporting teachers during the wartime period have become particularly relevant. In particular, the Digital Teacher programme was developed jointly with the Ministry of Education and Science of Ukraine (MESU) and Google.org to develop digital pedagogical competencies and support distance and blended learning (UNESCO and MESU..., 2023). This initiative aims to improve the digital skills of at least 50,000 teachers and includes modules on digital pedagogy, assessment, classroom management and support for teachers' psychological well-being. The programme also provides for the creation of a professional community for sharing experience and teaching methods (More than 48,000 Ukrainian..., 2024). Research on the digital transformation of higher education in Ukraine and the Czech Republic shows that, despite different institutional and resource conditions, both countries have demonstrated gradual adaptation to digital change after the COVID-19 pandemic. At the same time, universities face infrastructural constraints, but show a high level of flexibility and capacity for innovation through international cooperation (Danylyuk, 2025). In the field of language education in Ukraine, digital transformation is marked by uneven implementation, which is linked to varying levels of teachers' digital competency and infrastructural limitations. At the same time, research conducted within Erasmus+ projects shows that effective digital

transformation requires strategic coherence, the development of LMS systems and the integration of artificial intelligence into the educational process.

A separate area of UNESCO research focuses on the development of teachers' digital competencies, including the ethical use of artificial intelligence, open educational resources and digital literacy. This confirms the global trend towards a systemic approach to preparing teachers for the digital transformation of education (Kovalenko & Kuteimah, 2025). European guidelines for online and blended learning are also being developed. They cover digital pedagogy, inclusion, accessibility and the use of artificial intelligence in education as an integral component of the learning environment (Guidelines for online and blended learning..., 2024). The methodological basis of research into the digital transformation of education is formed at the intersection of three interrelated areas: theories of blended and online learning; concepts of open educational resources and digital competencies; and approaches to the integration of artificial intelligence and digital policy in education. Together, these areas form a multi-level framework for analysing educational change in the digital age. Summarising international and national experience, it can be stated that the digital transformation of education is now viewed as a socio-technical restructuring in which technology serves not merely as a tool, but as a catalyst for changes in the pedagogical paradigm, the roles of participants and the organisational structure of universities. The classic research by D.R. Garrison & N.D. Vaughan (2008) considers blended learning as the integration of classroom-based and online learning into a single pedagogically coherent system, in which the key issue is not the technological component, but the restructuring of educational interaction. In this model, the central aim is the development of so-called "communities of inquiry", in which learning occurs through communication between students, teachers and the digital environment. In the same vein, this model serves as a basis for interpreting hybrid education not only as a technological solution, but as a new didactic paradigm that alters the organisation of teaching, assessment and academic communication. The concept of open educational resources defines open educational resources as a strategic tool for expanding access to knowledge, reducing educational inequality and stimulating academic cooperation (Hylén, 2006). Methodologically, the presented concept provides a basis for a study of digital education from the positions of openness, the re-use of educational content and the reduction of barriers to access to educational content. Therefore, education can be viewed as an environment for the creation of shared knowledge and not as a system isolated from society. The research of R. Eynon & L.-E. Malmberg (2021) focuses on the connection between digital skills, learning activity and the quality of online learning. The authors argue that digital competency is a multifaceted phenomenon, which includes not only technical skills, but also critical thinking, the ability to self-regulate learning processes, and other skills for

autonomous learning. In methodological terms, this provides grounds for taking into account the behavioural and cognitive components of digital learning processes, not only infrastructural and technological ones.

H. Crompton & D. Burke (2023) consider artificial intelligence in higher education as a multilevel set of applications that can include the use of learning analytics and automated assessment, the development of individual learning trajectories and the use of artificial intelligence for administrative management optimisation. The authors stress that the main challenges lie not only in the technological implementation of AI, but also in issues of ethics, algorithmic transparency, academic integrity and the changing role of the teacher. This leads to the methodological conclusion that AI should be considered an element in the transformation of the educational ecosystem, rather than a separate tool. A key framework for analysing the digital transformation of education is DigCompEdu, developed by the European Commission. It defines the structure of teachers' digital competencies across six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital literacy. This framework makes it possible to standardise approaches to measuring the digital maturity of education systems and serves as a basic tool for comparative analysis of teachers' digital competency across countries (Punie & Redecker, 2017). The Digital Education Action Plan (n.d.) provides a strategic framework for the development of digital education in the EU, based on two priorities: the development of a digital education ecosystem and the formation of digital competencies throughout life. Thus, the theoretical and methodological basis of the study makes it possible to view digital transformation not as a set of separate technological innovations, but as a systemic process of restructuring the educational ecosystem, in which pedagogy, policy, technology and the human factor interact. In methodological terms, this document is relevant because it moves digital education from the level of individual innovations to the level of systemic policy covering infrastructure, pedagogy, governance and assessment. The national strategy for the digital transformation of education and science in Ukraine defines digitalisation as a key area in the modernisation of the education system. It includes the development of digital infrastructure, the improvement of teachers' digital competencies and the integration of educational technologies into the learning process. In methodological terms, this provides a basis for a study of the Ukrainian educational context as a system that is undergoing accelerated transformation as a result of external factors (such as war, globalisation) and internal factors (such as reforms, digitalisation) (Ukraine: Digital transformation..., n.d.). Thus, this structure of the concept allows understanding of the digital transformation of education as a systemic process for the reconstruction of the educational ecosystem, which includes pedagogical, legislative, technological and humanistic components interacting with each other.

Summarising approaches to the digitalisation of education on the basis of the preceding source analysis, it can be observed that the central substantive core of all these changes is the digital transformation of education. This transformation is not limited to the introduction of technological tools; rather, it involves restructuring the very logic of organising the educational process, managing knowledge and shaping interaction among participants in the educational environment. At the same time, technology is not considered to be a supplementary tool for the educational process but a system-building factor that transforms the way of learning, teaching and assessing the results of learning. In this process, a digital educational environment of a university forms that should be understood as an integrated ecosystem consisting of digital platforms, educational content and resources, administrative management systems and participants in the educational process. It functions as an integrated structure in which teachers, students, administrators and external educational services interact, while learning activity is carried out through a combination of different digital channels of communication and access to knowledge. Such an environment is dynamic and constantly changes under the influence of new technological solutions that expand the possibilities of learning and educational process management. Its functioning is supported by digital educational technologies, including learning management systems (LMSs), online platforms, video conferencing, interactive simulations and artificial intelligence as an important component of the digital educational environment. Artificial intelligence serves as a tool for implementing personalised educational trajectories, automated assessment, learning analytics and adaptive content that become part of the educational process.

Digital technologies have a fundamental impact on the organisational structures and management mechanisms of educational processes at universities. One of the main components is learning management systems (LMSs), where learning content, tasks, assessment tools and communication channels are concentrated. In the framework of the LMSs, learning takes a structured and modular form, when the teacher has the opportunity to plan the educational course, and the student has the possibility to independently choose the tempo and sequence of material. Online platforms and video communication technologies for remote learning change the types of learning interaction and provide access to educational resources. Educational materials are now accessible at any time and from anywhere, which helps to promote flexible and blended learning models. Video conferencing and interactive services change the nature of communication between the teacher and students by enabling synchronous and asynchronous interaction. At the same time, they reduce the share of direct face-to-face communication, which affects the quality of social interaction within the educational environment. The use of digital analytics and artificial intelligence fundamentally changes approaches to assessment, feedback and educational process management. Learning analytics

makes it possible to track students' progress in real time, identify problem areas and adapt learning content to individual needs. Artificial intelligence technologies can be included in the automation of assessment and support of pedagogical activities. These components contribute to the development of a flexible digital model for managing educational activities.

Blended learning, which combines traditional classroom-based teaching with digital and online elements, is becoming increasingly important. It allows combining the pedagogical advantages of face-to-face interaction with the teacher and the student in the classroom and the potential of digital learning platforms and tools, which leads to the flexibility of the organisation of the educational process and the expansion of its interactive space. Also, the model of remote learning can be singled out, in which, unlike the former model, the student is completely or mainly absent from the premises, and the process of learning is carried out using technologies for remote communication. This form of learning became particularly relevant in crisis situations, when continuity of education had to be ensured regardless of spatial and social constraints. All these forms of learning organisation share common features of the digital educational environment. First, this environment is marked by interactivity, which ensures active interaction between participants in the educational process and digital resources, thereby changing the traditional passive model

of learning. Another feature is flexibility, which makes it possible to adapt the pace, format and content of learning to the individual needs of learners. The model of accessibility is also worth highlighting, as it is characterised by the possibility of obtaining educational resources, taking into account the time and location of the person.

It is necessary to highlight the model of individualising education, which becomes possible by analysing data and using digital technologies, which allows the creation of the individual's educational programme and taking into account their needs, level of preparation and learning behaviour of students. All these trends are implemented with the help of technological mediation, which is characterised by a degree of dependency of the learning process on digital tools and technologies, which serve as the primary environment for the delivery of the learning process. As a consequence, conventional approaches to education are shifting to more complex digitally mediated approaches, where the learning process becomes more adaptive, collaborative, and individualised, and technology becomes a core element of the learning context. The generalisation of these approaches makes it possible to move to a comparative analysis of traditional and digital learning models, since their comparison most clearly demonstrates the depth of the transformations taking place in education. To systematise these differences, it is advisable to use the summary comparison Table 2.

Table 2. Comparative analysis of traditional and digital learning models

Criterion	Traditional learning model	Digital learning model
Learning format	Mainly classroom-based, fixed in time and space	Online, blended or hybrid, flexible in time and space
Nature of interaction	Direct, face-to-face, synchronous communication	Technologically mediated, with synchronous and asynchronous interaction through platforms
Role of the teacher	Main source of knowledge; transmitter of information	Facilitator, tutor, moderator of the educational process and designer of the learning environment
Role of the student	Mainly a passive listener; an object of the educational process	Active participant, subject of learning and co-creator of knowledge
Level of learner autonomy	Limited; dependent on the teacher and timetable	High; enables individual learning trajectories and selfregulation
Use of technology	Auxiliary, including presentations and basic digital resources	Key and system-forming, including LMSs, online platforms, AI tools and interactive environments
Access to learning materials	Limited by the classroom and physical resources	Continuous remote access to digital resources
Pace of learning	Uniform for the whole group	Individualised and adaptive
Assessment	Mainly summative and standardised	Continuous and formative, using digital analytics
Organisation of the educational process	Rigidly structured	Flexible, modular and adaptive
Educational environment	Physical space, namely the classroom	Digital educational environment as an integrated system of platforms and resources

Source: compiled by the authors based on UNESCO (n.d.), P. Black & D. Wiliam (1998), D.R. Garrison & H. Kanuka (2004), G. Siemens (2005), D. Laurillard (2012), G. Siemens & R.S.J.d. Baker (2012), C.R. Graham (2013), T. Bates (2019), OECD (2020)

The summary of the table shows that traditional and digital learning models differ fundamentally in the logic of educational process organisation. The traditional model is more rigidly structured, with the teacher playing the leading role and the student having limited autonomy, while technology performs an auxiliary function. In the digital

model, the system is flexible, collaborative, and heavily customised. In this model, the student becomes an active participant in learning, while the teacher acts as a facilitator. Technology assumes the status of a key element of the educational environment, ensuring accessibility, adaptability and a variety of learning formats. Overall, there

is a shift from a classic classroom-oriented system to a digital, student-centred model of education. Moving on from the comparative analysis of traditional and digital learning models, it is logical to deepen the discussion and proceed to a more structural level: the theoretical modelling of the digital educational environment of a university (Table 3). This approach makes it possible not only to identify the differences between educational models, but also to show

the internal architecture of the digital system, its elements and the nature of interaction between them. The university is a digital ecosystem open for the delivery of education through the interactions between actors and technological means. The main object of attention is not any separate part of it, but their combination into a single digital space in which the roles of the participants, communication forms, and knowledge access mechanisms are changing.

Table 3. Model of the digital educational environment of a university

Model element	Function in the system	Nature of interaction	Transformation of the role in the digital environment	Level of digital technology integration and examples
Teacher	Organisation and delivery of the educational process	Through LMSs, communication tools and digital content	From bearer of knowledge to facilitator, tutor and designer of the learning experience	Deep: LMSs + authoring tools, including Moodle, Google Classroom and Microsoft Teams
Student	Acquisition and construction of knowledge	Active interaction with digital platforms and the teacher	From passive consumer to active co-creator of the educational process	Deep: personalised trajectories in Moodle and adaptive learning systems
Digital platforms (LMSs)	Technological basis for organising learning	Centralised access to content, assessment and communication	Central infrastructural core of the ecosystem	Critical: Moodle, Canvas and Blackboard with H5P and BigBlueButton modules
Educational content	Content of learning	Multimedia-based, interactive and adaptive	Shift towards a personalised and interactive format	High: interactive videos (H5P), SCORM packages, simulations, VR/AR content and AI-based adaptive systems
Communication channels	Ensuring interaction between participants	Synchronous and asynchronous digital communication	Expansion towards continuous networked interaction	High: Zoom, Microsoft Teams, Discord, Moodle forums and Slack
Administrative systems	Management of the educational process	Integration with LMSs, analytics and automation	Shift towards data-driven management	Partial: USEDE, automated university management systems and API integration with Moodle, which is not always complete

Note: LMS – Learning Management System; H5P – HTML5 Package; SCORM – Sharable Content Object Reference Model; VR – Virtual Reality; AR – Augmented Reality; API – Application Programming Interface; USEDE – Unified State Electronic Database on Education

Source: compiled by the authors based on Digital Education Action Plan (n.d.), Y. Punie & C. Redecker (2017), OECD (2023), More than 48,000 Ukrainian teachers enrolled in UNESCO's "digital teacher" training (2024), Latest report addresses digital transformation in blended learning environments (2024), Rolling plan for ICT standardisation (2025), Digital education content: guidelines for teachers and interoperability framework (2026)

The digital educational environment of the university represents a socio-technical ecosystem of a unified system formed by combining all elements of the educational process (educational platforms and materials, information support, analytics, and administrative management systems). Such integration ensures not just technical interconnection, but the mutual dependence of parts of the system. This means that a change in the functioning of one of the components of the educational process, for example, LMS or evaluation system, automatically affects other levels and mechanisms of the educational process. As a result, the university environment acquires the features of an integrated digital system in which educational processes are managed through data and digital platforms. This system also includes a network structure with the distribution of the participants in the educational process and the interaction of digital technologies. In this sense, the learning ecosystem is not a hierarchical model, but a group of components, for example, LMSs, video conferences, cloud technologies, analytics platforms, which are interconnected. Data, learning resources, and feedback pass across them.

At the same time, the integration is uneven: some systems operate as the core of the digital infrastructure, while others remain fragmented or weakly connected, creating so-called "digital islands" and limiting the full seamlessness of the educational process.

Technological mediation is a means to transform the interaction between the pedagogical actors within the digital context. It implies replacing or complementing the direct contact between the teacher and the student with a set of digital channels like video lectures, message forums, chats, auto-evaluation systems, and learning management platforms. Technology performs not merely a function of transmission, but also influences the educational process, shaping its components such as material format, feedback dynamics, evaluation methods, and student activity levels. Thus, the educational interaction becomes mediated, algorithmised, and partially automated. Within this transformation, the roles of participants in the educational process are also changing. The teacher is gradually moving from the function of the main bearer of knowledge to the role of designer of the digital learning environment, facilitator,

tutor and learning data analyst who coordinates students' educational trajectories. The student transforms into an active subject who, on their own, directs their educational pathway, interacts through digital tools and contributes to the process of creating knowledge. In general, systemic integration, networked structure, technology and changing roles are the components that create a new model of the university as an open digital ecosystem that is oriented on data, interaction and adaptation. Overall, the study findings confirm that the digital transformation of education is not merely a stage of modernisation, but a systemic change in the educational paradigm. It forms a new model of the university environment that combines a high degree of technological mediation, deep integration of digital systems, individualisation of learning and networked forms of interaction. This opens up prospects for the further development of education as a flexible, adaptive and innovative system capable of responding to societal challenges.

DISCUSSION

The findings obtained in the study of the digital transformation of education make it possible to move on to their interpretation and comparison with the studies of other scholars. The generalisation of approaches shows that the digitalisation of the educational environment is a multi-dimensional process that includes not only technological change, but also deeper transformations in pedagogical models, management approaches and the roles of participants in the educational process. In this regard, it is important to compare the findings with those of previous studies in order to determine the degree of consistency between them, confirm theoretical assumptions and identify possible scholarly divergences. V.M. Prylypko *et al.* (2023) also examined the issue of professional development among teachers in Ukrainian higher education institutions under conditions of digital transformation. The authors analysed the requirements for the digital competencies of academic staff, examined existing professional development systems and proposed ways to improve them. Emphasis is placed on the need for systematic, continuous and purposeful training to prepare teachers for work in a digital educational environment. Systemic barriers to the digitalisation of education are examined separately. A. Singun (2025) conducted a systematic review of barriers to digital transformation in higher education. The scholar identified key challenges, including insufficient digital competencies and the limited technological readiness of institutions. Digital literacy is considered a basic element in the transformation of education. S. Farias-Gaytan *et al.* (2023) analysed the relationship between digital transformation and digital literacy. The researchers noted that the level of digital competencies is a factor in the success of educational reforms. The development of digital learning as a new model of education is the subject of separate studies. M. Alenezi (2023) examined the concept of digital learning and digital universities. The author defined the digital environment as a new form of educational organisation based on technological integration

and flexible educational models. Despite the number of existing studies, the comprehensive modelling of the digital educational environment of a university as an integrated system remains insufficiently explored. Further analysis is also required of the transformation of the roles of teachers and students under conditions of full digitalisation, as well as the interaction between different elements of the educational ecosystem in hybrid learning models.

The digital transformation of education is viewed as a systemic process that alters both the technological tools and the underlying logic of the educational environment; this is consistent with the findings of S. Timotheou *et al.* (2023), who analysed the impact of digital technologies on education and described their role in transforming educational structures. The researchers stated that digitalisation encompasses the technological and institutional changes that contribute to the emerging educational model. The transition from traditional teaching models to flexible digital systems is a natural consequence of the digitalisation of education. This is consistent with O.B. Aded & E. Soykan (2023), who examined the transformation of learning under the influence of online education during the COVID-19 pandemic. The authors noted that digital learning models increase the flexibility of the educational process, but at the same time create new challenges. The digital educational environment of a university is formed as an integrated ecosystem of interaction between technology, people and management processes. This is consistent with J. Paul *et al.* (2024), who analysed digital transformation as an interdisciplinary phenomenon. The study notes that digital education systems function as complex ecosystems that bring together different levels of management and learning.

The findings confirm that the digital transformation of higher education is a systemic socio-technical restructuring in which technology becomes not only a tool, but also a structuring element of the educational environment. This is consistent with the conclusions of I.O. Pappas *et al.* (2023), who examined responsible digital transformation and noted that successful digital transformation is possible only when technological, social and ethical aspects are considered comprehensively. This fully corresponds to the model of the digital educational environment of a university developed in the study. The findings of the study reveal a significant increase in the availability of education and its flexibility due to the introduction of online and blended formats. These conclusions are consistent with the studies by M. Alojail & S.B. Khan (2023) and Q. Xu *et al.* (2023), whose authors analysed the impact of digital transformation on sustainable development and showed that digitalisation significantly improves access to services, including educational services, while also requiring new competencies from all participants in the process. The identified pedagogical challenges related to changes in the roles of teachers and students, as well as the need to develop digital competencies, are in line with the findings of A. Essien *et al.* (2024). The researchers examined the impact of

generative artificial intelligence on students' critical thinking in British business schools and emphasised that the introduction of AI requires a reconsideration of the teacher's role as a facilitator and the activation of students as co-creators of knowledge. The findings on the uneven nature of digital transformation in Ukrainian universities and the need for the systematic integration of platforms are consistent with the position of M. Kanan *et al.* (2023). The authors analysed the transformation of universities towards entrepreneurial models and concluded that the comprehensive implementation of digital management practices and innovation is a key factor in the successful transformation of higher education institutions. Thus, the findings of the present study not only confirm but also specify, in a pedagogical context, the general patterns of digital transformation identified in contemporary scholarly literature.

Digital technologies function not as an auxiliary element, but as a structuring element of education. This is consistent with C. Wang *et al.* (2024) examined global trends in the digitalisation of education. The authors demonstrated that technologies change the very structure of education systems, influencing their organisation and functioning. The role of the teacher is transformed from bearer of knowledge to facilitator and organiser of the learning process. This is consistent with B. George & O. Wooden (2023), who examined the use of artificial intelligence in managing educational transformations. The researchers noted that, in a digital environment, the teacher becomes a guide and support for the student. The student turns into an active subject in the digital environment and forms their own educational trajectory. Y. Li *et al.* (2024) researched how digital educational games impact students' motivation. The authors argue that the digital environment promotes learners' increased motivation and independent learning. Digitalisation of education fosters the development of student autonomy and self-regulation of learning, which is consistent with the findings of S. Dziubaniuk *et al.* (2023), who studied learning in a digital environment using connectivism theory. The study notes that a digital environment stimulates independence and a network form of learning. Digital educational technologies ensure continuity in the learning process regardless of the location and time of the educational process. This corresponds to O.B. Adedoyin & E. Soykan (2023), who identified the role of online learning during the pandemic period. The authors noted that digital technologies became an important mechanism in maintaining educational continuity. Blended learning serves as the most effective model for integrating traditional and digital education. This is consistent with Y. Zou *et al.* (2025), who examined trends in digital learning. The study emphasises that hybrid models are among the most resilient and adaptive forms of education.

Distance learning performs the function of ensuring educational resilience in crisis conditions. This is consistent with S. Saeed *et al.* (2023), who analysed digital transformation under conditions of cyber threats and crises. The researchers noted that online education is relevant to the

stability of education systems. Digital platforms, particularly LMSs, form the central core of educational process organisation. This is consistent with M.H. Al Najdawi *et al.* (2024), who examined the use of digital technologies in higher education. The authors emphasised that LMSs provide the basis for managing learning and assessment. Digitalisation expands access to education and reduces territorial constraints on the learning process. This is consistent with O.B. Adedoyin & E. Soykan (2023), who showed that online learning increases the accessibility of education for different social groups. Education becomes more interactive through digital interaction between participants in the process. This is consistent with M. Liu *et al.* (2023), who examined the use of generative artificial intelligence in education. The authors noted that digital tools enhance the interactivity of learning. Educational content is transformed into a multimedia and adaptive format oriented towards different learning styles. This is consistent with Y. Li *et al.* (2024), who showed that the digital environment makes it possible to create adaptive learning materials that take students' needs into account. Assessment in the digital environment is gradually becoming formative and continuous. This is consistent with S. Timotheou *et al.* (2023), who noted that digital technologies change approaches to assessment and the monitoring of learning outcomes.

Digital analytics is becoming a tool for monitoring students' academic achievement. This is consistent with B. George & O. Wooden (2023), who emphasised the role of data analytics in improving the effectiveness of educational management. The educational process is becoming more personalised through digital technologies and adaptive learning systems. This is consistent with M.H. Al Najdawi *et al.* (2024), who showed that artificial intelligence makes it possible to predict and adapt students' educational trajectories. Digital transformation changes the structure of academic communication, making it networked and multi-channel. This is consistent with J. Paul *et al.* (2024), who noted that digital systems create new forms of communication between participants in the educational process. Education is moving from a linear model of knowledge transmission to an interactive and flexible learning system. This is consistent with S. Timotheou *et al.* (2023), who emphasised that digitalisation changes the classical structure of the learning process. The digital transformation of education is not merely technological modernisation, but a profound change in the educational paradigm. This is consistent with S. Bianchini *et al.* (2023), who considered digital transformation as part of broader systemic changes in society and education. The authors stressed that digitalisation has a long-term structural impact. The generalisation of the study findings makes it possible to state that the digital transformation of education is a complex and multi-level process that covers both the institutional and pedagogical dimensions of the functioning of the education system. It was established that digital technologies act as a system-forming element of the educational environment, changing the nature of interaction

between teacher and student, the structure of the learning process and approaches to assessing learning outcomes. It is also noted that digitalisation fosters the development of flexibility, access, and personalisation in education, which forms a new educational paradigm based on the student, the student's autonomy, and the continuity of learning. Overall, the findings confirm that digital transformation is not merely a stage of modernisation, but a fundamental change in the logic according to which education functions.

CONCLUSIONS

The digital transformation of education is not a local process of technology implementation, but a systemic restructuring of the entire educational paradigm, covering the organisational, pedagogical and communicative levels of the university environment. It has been confirmed that higher education is gradually moving from the traditional model of knowledge transmission to a digital networked ecosystem in which technology performs not an auxiliary, but a structuring function. It was established that the digital transformation of education is reflected in a change in the logic of the educational process: from fixed classroom-based formats to flexible, adaptive and blended learning models. This is accompanied by a shift towards a student-centred educational paradigm, in which the student acts as an active subject of learning, while the teacher is transformed from a bearer of knowledge into a facilitator, tutor and designer of the educational environment. Changes in roles are among the most important quality results of the digitalisation of education.

The digital educational environment at the university is represented by an integrated system that combines digital platforms, learning content, communication systems and administrative services. In the university's digital educational environment, all educational processes are mediated by technology, which ensures continuity in the educational process, accessibility and opportunities to personalise learning paths. A qualitatively new outcome is the formation of a networked structure of the educational process, in which interaction between participants is continuous, multi-channel and dynamic. The findings also confirm that digital educational technologies, including LMSs, online platforms, video communication and

interactive tools, have become a basic infrastructural component of education. They ensure not only the transmission of educational content, but also assessment, analytics, learning process management and feedback. This brings a qualitative change to the organisation of learning, making it more flexible, modular and personalised.

The introduction of digital approaches substantially expands access to education and increases its flexibility. At the same time, the digital competencies of teachers and students become increasingly important as a key factor in the effectiveness of the educational process. The absence or low level of such competencies remains one of the main barriers to high-quality digital transformation. The comparative analysis revealed differences between traditional and digital learning models. Whereas the traditional model is characterised by rigid structure, limited student autonomy and the dominance of the teacher, the digital model is based on interactivity, flexibility, personalisation and the active role of the student. This indicates a transition from a vertical to a horizontal, networked logic of educational interaction.

The theoretical modelling of the digital educational environment of a university made it possible to establish that all its elements, including the teacher, the student, platforms, content, communication systems and administrative systems, function as a single interconnected system. A change in one element automatically affects the transformation of the entire educational ecosystem, confirming its systemic and dynamic nature. Further research should focus on the empirical testing of the effectiveness of digital educational models in different types of higher education institutions, as well as on studying the impact of artificial intelligence on the individualisation and quality of the learning process.

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Цифрова трансформація освітнього середовища університетів: педагогічні виклики та соціальні наслідки

Анотація. Метою дослідження було комплексне обґрунтування цифрової трансформації вищої освіти. Методологія включала аналіз наукових джерел і стратегічних документів у сфері цифрової трансформації освіти, концептуалізацію ключових понять, порівняльний аналіз традиційної та цифрової моделей навчання, а також структурно-функціональне моделювання. Основні результати дослідження полягали в тому, що було системно узагальнено цифрову трансформацію освіти як багаторівневий процес, який одночасно охоплює педагогічний, технологічний та організаційний виміри функціонування університету. Було визначено та концептуально уточнено поняття «цифрове освітнє середовище університету» як інтегровану екосистему, що включає цифрові платформи, освітній контент, комунікаційні канали, адміністративні системи та учасників освітнього процесу, які взаємодіють у мережевій цифровій структурі. У результаті дослідження встановлено, що цифрова трансформація призводить до системної зміни ролей учасників освітнього процесу: викладач трансформується з носія знань у фасилітатора та дизайнера навчального середовища, а студент набуває статусу активного суб'єкта та співтворця знань. Виявлено, що ключовими характеристиками цифрового освітнього середовища є інтерактивність, гнучкість, доступність, персоналізація та технологічна опосередкованість. Доведено, що цифрові освітні технології (LMS, онлайн-платформи, відеокommунікація, інтерактивні інструменти) стають центральним елементом організації навчального процесу, забезпечуючи не лише передачу знань, а й управління навчанням, оцінювання, аналітику освітньої діяльності та формування індивідуальних освітніх траєкторій. Також було розроблено структурну модель цифрового освітнього середовища університету, яка підтверджує, що ефективність освітнього процесу залежить від інтеграції всіх компонентів у єдину цифрову систему, де взаємодія між елементами є безперервною, адаптивною та технологічно опосередкованою. Практичне значення результатів дослідження полягає у можливості їх використання для проєктування та вдосконалення цифрових освітніх середовищ у закладах вищої освіти, розробки стратегій впровадження змішаного та дистанційного навчання, а також підвищення ефективності управління освітнім процесом.

Ключові слова: технологічна опосередкованість; індивідуальні траєкторії; адміністративні системи; змішане навчання; освітній контент