A Comprehensive model for evaluating the quality of digital teaching and learning in Ukrainian universities

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Abstract
This article is devoted to the development of a comprehensive model for evaluating the quality of digital learning in Ukrainian higher education institutions. The proposed multidimensional model includes five key components: technological readiness, organizational maturity, pedagogical effectiveness, professional staff readiness, and user satisfaction. An empirical study covered 17 Ukrainian universities and 344 respondents. The results showed heterogeneity in digital education development: high levels of basic technology adoption alongside critical gaps in electronic document management and teacher training. Broad support for hybrid learning and the need for platform standardization were identified. A quality level system and practical recommendations for improving digital educational process efficiency under modern challenges were developed.

Keywords
digital learning, education quality, higher education, digital transformation, pedagogical effectiveness, hybrid learning, technological readiness, organizational maturity, professional staff training

1. Introduction

The domestic higher education system is undergoing fundamental changes as a result of rapid digital transformation caused by global trends and specific national conditions. Digital transformation of the educational environment has become particularly relevant under global challenges related to the COVID-19 pandemic and military actions in Ukraine, which accelerated the transition to distance and blended learning formats. Higher education institutions face the need to ensure high quality educational services under conditions of mass transition to distance and blended learning forms. This creates a need for developing new methodological approaches to evaluating the effectiveness of digital educational processes, as traditional criteria for assessing education quality do not fully account for the specifics of digital environments.

Technological Foundation and Infrastructure Readiness as the Basis for Digital Learning Quality. The conceptual foundations of digital education quality as a prerequisite for educational system development are explored by Huraliuk A.H., who substantiates the significance of technological innovations for enhancing educational standards [1]. An empirical analysis of e-learning course effectiveness is conducted by Mund J.-P., Khrutba V.A., Wallor E., Holovko A.A., Nikitchenko Yu.S., and Khrutba Yu.S., who investigate students' and instructors' perspectives on improving digital educational resources [2]. These studies confirm the critical role of stable technological infrastructure and digital platform accessibility in ensuring educational process quality, which constitutes the first component of comprehensive digital learning quality assessment.

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Organizational Maturity and Management Practices in Digital Transformation. Areshonkov V.Yu. formulates strategic objectives for higher education institution leadership regarding effective digital solution implementation, emphasizing the role of management practices in ensuring the success of transformation processes [3]. Institutional challenges of digitalization are analyzed by Karpliuk S.O., who identifies specific barriers in adapting traditional educational structures to digital environment requirements [4]. These works substantiate the necessity of systematic strategic planning, process standardization, and institutional support as key elements of university organizational maturity in the context of digitalization.

Pedagogical Effectiveness of Digital Teaching Methods. The multidimensional nature of digital transformation is examined by Lykhodieieva H.V., Diorditsa I.M., and Katerynych P.V., who position digitalization as a catalyst for social progress from a psychological-pedagogical perspective [5]. Specific wartime conditions for organizing distance learning assessment are analyzed by Holovko S., Zhuk Yu., and Naumenko S., who develop adaptive methods for monitoring academic achievement [6]. These studies demonstrate the importance of aligning digital methods with pedagogical objectives, ensuring learning content interactivity, and providing timely feedback to achieve high pedagogical effectiveness in digital learning.

Digital Competence and Preparedness of Teaching Staff. A comprehensive model of students' digital competencies was developed by Borodkina I. and Borodkin H., proposing a systematic approach to developing technological literacy in the information society [7]. The globalization context of digital culture formation is investigated by Kononenko L., Oryshaka O., and Selishcheva Ye., who consider digital competence as a strategic factor in educational institutions' competitiveness [8]. While these studies focus primarily on students, they underscore the critical importance of digital competence for all participants in the educational process, including instructors, whose professional readiness, motivation, and systematic training are necessary conditions for successful digital transformation.

Adaptability of Digital Learning Under Crisis Challenges. Current challenges of emergency digitalization under crisis conditions are analyzed by Bekhta I.A. and Kovalevska T.I., who conceptualize adaptive mechanisms of the educational process as a response to emergency situations, including pandemic restrictions and military actions [9]. Practical aspects of digital transformation are examined by Dukhanina N. and Lesyk H., who systematize problems of technological innovation integration and outline prospects for balanced digital solution implementation [10]. These studies actualize issues of user satisfaction and learning experience, especially under extreme conditions, when the convenience, accessibility, and psychological comfort of the digital environment acquire particular significance for maintaining learning motivation and effectiveness.

Gap in Existing Research and the Need for a Comprehensive Approach. Analysis of the scientific literature indicates insufficient development of methodological approaches to comprehensive digital learning quality assessment. Existing research predominantly focuses on individual aspects of educational digitalization – technological innovations [1, 2], organizational challenges [3, 4], pedagogical methods [5, 6], participant competencies [7, 8], or crisis adaptations [9, 10] – without forming a holistic understanding of digital educational process quality criteria and indicators. An integrated instrument is lacking that would simultaneously account for technological readiness, organizational maturity, pedagogical effectiveness, staff professional preparedness, and user satisfaction as interconnected components of a unified quality assessment system.

This creates a need for developing a comprehensive assessment model that would integrate all key dimensions of digital learning quality into a unified system. The particular relevance of such an approach is determined by the specific conditions of Ukrainian higher education functioning during the COVID-19 pandemic and martial law, when forced large-scale digitalization requires not only technological solutions but also a systematic approach to ensuring and monitoring educational process quality. The developed model should enable comprehensive diagnostics of digital learning status, identification of problem areas, and formation of improvement strategies at all levels – from individual courses to institutional policy of higher education institutions.

2. Problem

The forced transition to distance learning in 2020 became a challenge for all educational process participants, revealing significant gaps in Ukrainian universities' readiness for digital transformation. Higher education institutions' readiness to implement digital technologies proved heterogeneous, leading to a complex of technical, organizational, and pedagogical problems. Main problems included insufficient technical infrastructure, including limited internet access and modern equipment, as well as lack of educational materials adapted for digital environments. Particularly acute was the problem of university administration and faculty unpreparedness for organizing quality distance learning. Organizing effective learning processes using digital technologies, motivating students for active participation in online learning, and overcoming technical obstacles proved significantly more complex tasks than expected. The educational process often reduced to mechanical material distribution and formal task completion, leading to decreased education quality and participant fatigue.

Further situation complication is related to the beginning of military actions in Ukraine, which dealt an additional blow to the higher education system. Destruction of educational infrastructure, human capital problems, and the need to organize educational processes under martial law conditions became additional challenges for educational digitalization. Under these conditions, the issue of university digital transformation became a question of their survival and maintaining educational service quality. Each university is forced to seek its own model of effective digital transformation implementation, actualizing the need for scientifically grounded criteria and methods for evaluating digital educational process quality.

Analysis of the current state shows that successful digital transformation requires not only technological solutions but also formation of a new organizational culture that promotes active use of digital technologies in all aspects of the learning process and university management. It is necessary to create a comprehensive system of values, approaches, practices, and skills that forms digitalization culture in higher education institutions. Simultaneously, the absence of unified standards and criteria for evaluating digital learning quality complicates monitoring processes of digital transformation effectiveness and making informed management decisions. This creates a need for developing a comprehensive evaluation model that would ensure a systematic approach to measuring and improving digital education quality in Ukrainian universities.

The research aim is to develop and empirically validate a comprehensive model for evaluating digital learning quality in Ukrainian higher education institutions to determine strategic directions for improving digital education effectiveness.

3. Theoretical foundations of digital learning quality assessment

3.1. Research methodology

Digital learning is defined as a process of knowledge, skills, and competency acquisition by students through interaction with digital learning environments, characterized by active technology use for independent work, collaboration, critical thinking, and professional development.

Digital learning quality assessment is understood as a comprehensive process of systematic analysis and measurement of educational process quality conducted using digital technologies, aimed at determining correspondence of achieved results to established standards, stakeholder expectations, and educational institution strategic goals.

Digital learning quality is a multifaceted concept including interconnected components: technological readiness, organizational maturity, pedagogical effectiveness, professional staff readiness, and user satisfaction.

Technological readiness encompasses stability and accessibility of digital infrastructure, interface convenience, and user technical support. It includes internet connection quality, equipment modernity, and platform reliability.

Organizational maturity includes the presence of digitalization strategy, staff training systems, process standardization, and quality monitoring. It determines systematic approach to digital transformation.

Pedagogical effectiveness represents correspondence of digital methods to learning objectives, content interactivity, timely feedback, and adaptation to different learning styles. It shows how technologies improve learning outcomes.

Professional staff readiness encompasses faculty digital competency levels, their training and support systems, and motivation to use new technologies.

User satisfaction represents perception of digital tool convenience and usefulness, motivation for their use, and achievement of expected learning outcomes (Figure 1).

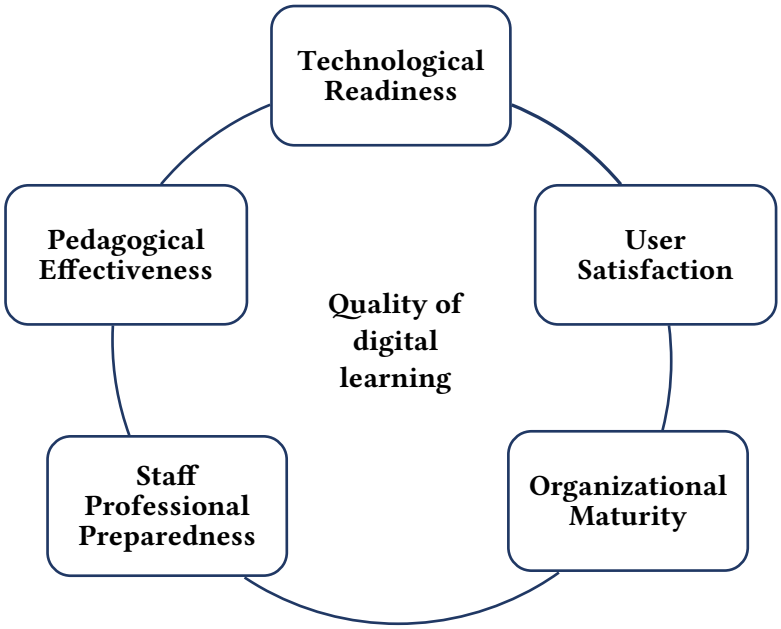

Figure 1: Structure of the Comprehensive Model for Digital Learning Quality Assessment.

The presented model demonstrates five interconnected components of digital learning quality, emphasizing the systemic and integrated nature of educational environment digital transformation. Each component influences and depends on the others, which requires a comprehensive approach to assessing and improving digital learning quality.

Specific Features of Digital Learning Quality Assessment

Multifaceted approach is the first feature of such assessment. It encompasses technological aspects (platform stability, interface convenience), pedagogical moments (technology assistance in better material acquisition), organizational issues (systematic innovation implementation), and most importantly, user satisfaction - students, faculty, and administration.

Process continuity is the second key characteristic. Quality assessment does not occur once a year as a formal procedure. It is a constant cycle: first determining what to assess and how, then collecting information, analyzing results, making change decisions, and returning to assessment of the updated system.

Considering different perspectives makes assessment truly objective. Students evaluate convenience and learning effectiveness, faculty assess pedagogical possibilities and technical learning support, administration analyzes economic feasibility and strategic correspondence, and employers verify whether graduate competencies meet real labor market needs.

Digital Learning Quality Assessment Levels

Quality assessment occurs at different levels, each with its specifics.

At individual course level, attention focuses on specific details: digital content quality, interactive element functionality, student engagement in learning process, and their results. This is the closest level to students where direct technology impact on learning can be observed.

At educational program, specialty, or faculty level, the picture becomes broader. Here it is important whether digital technologies are systematically used throughout the entire learning period, whether students' digital competencies develop consistently, and whether faculty are prepared to work with new tools.

At entire higher education institution level, assessment addresses strategic issues: whether there is a clear vision of the institution's digital future, whether technological infrastructure is adequate, whether innovation culture is formed, and what place the university occupies among other educational institutions.

Digital Learning Quality Assessment Methods

Quantitative methods provide objective, statistically significant data through learning analytics metrics analysis, test results, activity indicators, and system technical parameters. These methods allow trend identification, comparison of different approach effectiveness, and result prediction. This can include analysis of how students use learning platforms (time spent, materials worked with), system technical performance indicators (speed, reliability), or academic results (grades, successful course completion percentage).

Qualitative methods reveal context, motivation, and subjective participant experience. Through interviews, surveys, and observations, one can learn about real technology use experience, problems and obstacles users face, their needs and expectations.

Mixed methods integrate advantages of both approaches, providing the most complete picture of digital learning quality and forming a basis for making informed decisions on improvement.

3.2. Comprehensive quality assessment of digital learning in Ukrainian universities

The research is based on mixed methodology principles, providing integration of quantitative and qualitative approaches to data collection and analysis. Empirical research was conducted within the international project "Ukrainian-German Educational Network for Digital Transformation of Environmental Education", implemented with support from the German Academic Exchange Service (DAAD) in cooperation with Eberswalde University for Sustainable Development and Ukrainian higher education institutions [11].

The project aims to achieve sustainable development goals, particularly SDG 4 "Quality Education", and promotes implementation of European educational standards through digital transformation [12]. International partnership ensures experience exchange, innovation testing, and sustainable educational ecosystem formation.

The empirical base was formed based on a representative sample of 17 Ukrainian higher education institutions representing different regions and specializations. The total number of respondents was 344 people, including 166 academic staff members (48,3%) and 178 students (51,7%) (Figure 2). This sample structure ensures balanced representation of main educational process participants' views and enables comparative analysis of their assessments.

The research focused on analyzing understanding of digital transformation essence, digital platform usage practices, administrative process automation levels, informal online education support, and hybrid learning application. Research tools included structured online questionnaires with various question types, digital platform use observations, educational infrastructure technical characteristics analysis, and organizational process assessment.

The validity of the proposed digital learning quality assessment model was confirmed using the expert evaluation method. Validation participants included specialists in digital education and educational technologies from various Ukrainian higher education institutions with five to fifteen years of experience in educational digitalization. The experts validated the alignment of the model's five components (technological readiness, organizational maturity, pedagogical effectiveness, staff professional preparedness, user satisfaction) with the real-world practice of digital transformation in Ukrainian universities. The experts gave particular attention to the relevance of assessment indicators for each component, confirming their practical significance and applicability within the Ukrainian educational context.

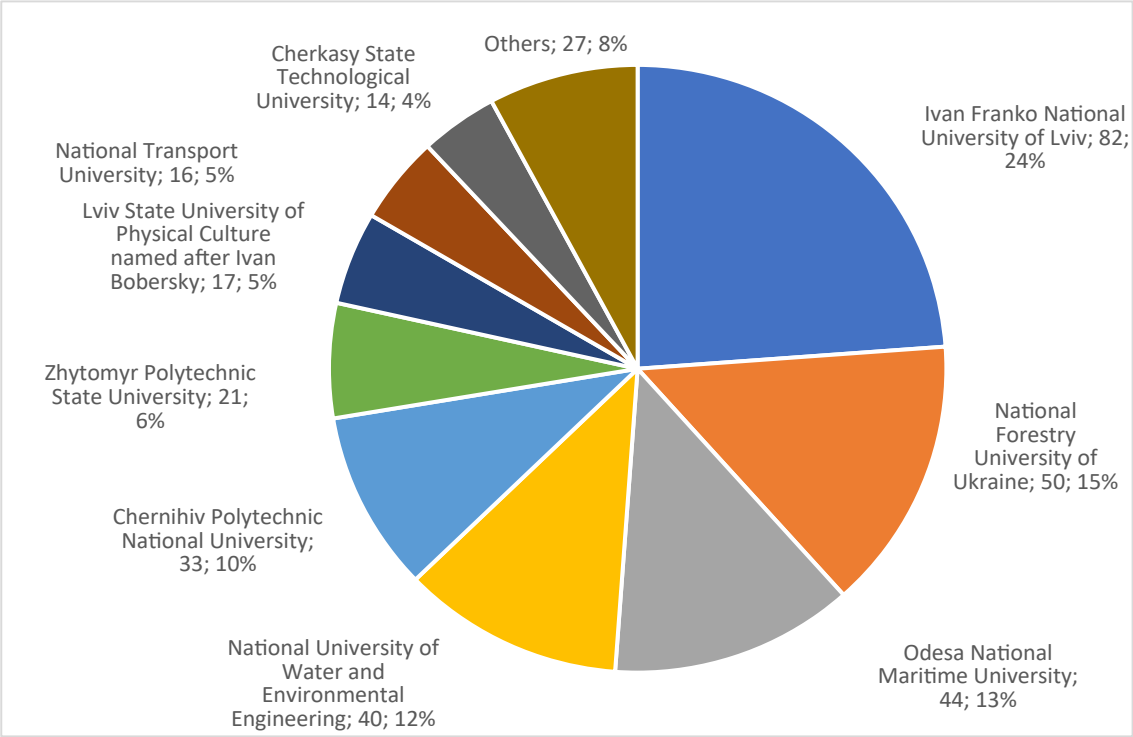

Figure 2: Survey sample structure by Ukrainian HEIs.

The consensus evaluation by experts confirmed the comprehensiveness and balance of the model, enabling its use as an instrument for systematic assessment, monitoring, and improvement of digital learning quality in higher education institutions. Expert validation also confirmed the model's relevance for crisis digitalization conditions caused by the COVID-19 pandemic and martial law in Ukraine.

4. Empirical research results

4.1. Technological readiness and digital infrastructure

Technological Readiness

Assessment of technological component of digital learning quality through analysis of digital platform availability and effective use, technical infrastructure state, and its impact on educational processes. It determines how technical conditions promote or hinder achieving high learning quality.

Use of Digital Platforms and Tools

Analysis of different digital tool category use frequency (learning platforms, communication means, content tools, assessment tools, innovative technologies) to determine technological implementation level and digital learning readiness (Table 1).

Clear technological implementation stratification is observed. Basic platforms (MOODLE, Zoom) achieved high adoption levels, indicating successful completion of the first digital transformation stage. Notable is rapid AI-technology adoption (index 0,70), demonstrating educational community adaptability.

Table 1
Digital Platform and Tool Usage Levels

Category	Tool/ Platform	Often, %	Periodically, %	Never, %	Usage Index*
Learning Platforms	MOODLE	62,2	17,4	7,8	0,80
	Google Classroom	24,7	24,4	25,3	0,50
Communication Tools	Zoom	51,5	35,5	4,9	0,87
	Microsoft Teams	29,9	23,3	21,5	0,53
Content Tools	Educational videos from internet	29,9	44,5	7,3	0,74
	Own lecture recordings	18,0	28,8	24,1	0,47
	Canva	18,6	31,7	19,2	0,50
Assessment Tools	Tests and quizzes	32,0	34,3	10,5	0,66
	Kahoot	2,6	16,9	34,6	0,19
Innovative Technologies	AI tools (GPT)	31,7	38,7	10,8	0,70
	VR/AR technologies	0,9	16,3	45,9	0,17

*Usage Index = (Often×1 + Periodically×0,5) / 100

Technical Infrastructure State

Assessment of basic technical conditions for digital learning: internet connection quality in different university locations, technical equipment state, digital environment organization, and platform selection approaches (Table 2).

Table 2
Technological Readiness of Higher Education Institutions

Infrastructure Component	Indicator	Percentage	State Assessment
Internet connection in academic buildings	Good	43,0%	Satisfactory
	Average	37,5%	
	Poor/absent	19,5%	
Internet connection in dormitories	Good	32,0%	Critical
	Average	42,4%	
	Poor/absent	25,6%	
Technical equipment	Modern and accessible	34,6%	Critical
	Partially suitable	45,1%	
	Outdated/insufficient	20,3%	
Digital environment organization	Centralized platform selection	45,3%	Satisfactory
	Independent teacher selection	31,1%	
	Single platform support	67,7%	Good

Technical infrastructure demonstrates serious imbalances. Critical is the difference in internet connection quality between academic buildings and dormitories (43% vs 32% "good"), creating a digital divide. Equipment obsolescence (only 34,6% modern) limits innovative technology implementation.

Organizational Maturity

Measuring organizational process quality that ensures digital learning. Assessing strategic planning effectiveness, action coordination, process automation, and their impact on overall digital educational process quality.

Strategic Planning and Awareness

Analysis of educational process participants' awareness level about existence and content of digital learning strategy in their institutions, reflecting internal communication effectiveness and strategic planning (Table 3).

Table 3

Strategic Awareness Level of Educational Process Participants

Aspect	Academic Staff, %	Students, %
Knowledge about HEI strategy existence	45,2	43,3
Understanding strategy goals	44,6	44,4
Don't know/difficult to answer	40,4	45,5

Strategic awareness demonstrates critical internal communication problems in Ukrainian universities. Less than half of respondents (44-45%) know about digital learning strategy existence in their institution, indicating insufficient strategic planning transparency. Particularly alarming is that almost half of educational process participants (40-45%) completely lack information about their university's strategic development directions. This creates risks of fragmented digital technology implementation and reduces systematic transformation effectiveness.

Administrative Process Automation

Assessment of university administrative process digitalization degree: automated management system use, electronic schedule implementation, electronic document flow development, and their effectiveness (Table 4).

Table 4

Administrative Process Digitalization State

Process	Indicator	Percentage	Maturity Level
Automated "Decanate" system	Use personally	37,5%	Medium
	Don't use	31,7%	
	No problems	72,7%	
Electronic schedule	Available	82,6%	High
	Convenient and current	64,0%	
Electronic document flow	Primary	14,5%	Low
	Partial	49,1%	
	Duplicated on paper	25,0%	

Organizational maturity is characterized by unevenness. Successful electronic schedule implementation (82,6%) contrasts with critically low electronic document flow level (14,5% primary).

Low strategic awareness (40-45% lack information) is a serious obstacle to systematic digital transformation.

Pedagogical Effectiveness

Assessment of learning outcome quality achieved through digital technology use. Measuring different digital learning format effectiveness, their suitability for different class types, and impact on improving student educational achievements.

Hybrid Learning

Analysis of attitudes toward hybrid learning format, its perception by different participant groups, and assessment of suitability for different class types (lectures, seminars, laboratory work, etc.) (Table 5).

Table 5

Attitudes Toward Hybrid Learning and Its Application

Parameter	Academic Staff, %	Students, %	Support Level
General attitude toward hybrid learning			
Depends on discipline/specifics	65,7	50,6	High
Unconditionally effective	30,7	41,6	Medium
Don't consider appropriate	3,6	7,9	Low
Suitability for different class types			
Lectures	83,7	81,5	High
Consultations and make-up sessions	69,9	64,0	High
Seminars/practical classes	54,8	54,5	Medium
Laboratory work	17,5	37,6	Low (discrepancy)

Digital Material Use

Assessment of faculty digital educational material use intensity (presentations, video lectures, interactive assignments, etc.) in classroom learning as an indicator of technology integration into pedagogical processes (Table 6).

Table 6

Academic Staff Digital Material Use Intensity

Usage Level	Academic Staff, %	Characteristics
Most/almost all	63,9%	High integration level
Approximately one third	21,1%	Medium level
Minimally	15,0%	Low level

Hybrid learning received almost universal recognition (96,4% faculty and 92,1% students). Critical discrepancy is observed regarding laboratory work: students consider them twice as suitable for hybrid format, possibly indicating faculty underestimation of virtual laboratory possibilities.

Professional Staff Readiness

Assessment of faculty preparation and competency quality as a key factor in ensuring quality digital learning. Analyzing correspondence of staff preparation level to digital education requirements and their ability to ensure high learning standards.

Faculty Training System

Analysis of faculty provision with digital technology training and education, assessing existing training program effectiveness and identifying professional development gaps (Table 7).

Table 7
Academic Staff Professional Development in Digital Technologies

Training Aspect	Indicator	Percentage	Provision Level
Learning platform training	Formalized by university	84,9%	High
	Need exists, not conducted	3,0%	
Digital tool training	Formalized by university	44,0%	Critically low
	Need exists, not conducted	26,5%	
Training effectiveness	Fully useful	40,4%	Moderate effectiveness
	Partially effective	36,1%	
	Self-learning	16,3%	

Critical gap in preparation is observed: high level of basic training (84,9%) contrasts with deficit in modern tool training (44%). Every fourth academic staff member (26,5%) needs additional training. Students demonstrate higher adaptability to technological changes.

Digital Technology Adaptation

Assessment of how different educational process participant groups perceive changes from digital technology implementation, their readiness for adaptation, and identifying barriers in new tool learning process (Table 8).

Table 8
Perception of Changes from Digital Technology Implementation

Assessment Aspect	Academic Staff, %	Students, %	Interpretation
Became more convenient, but improvements needed	45,8	57,3	Students more optimistic
Increased opportunities and freedom	39,8	34,3	Academic staff value flexibility
Spend more time learning	7,2	1,7	Academic staff have greater difficulties

User Satisfaction

Studies how positively educational process participants perceive digital innovations and how comfortable they feel using them. Examining technology acceptance degree, digital tool work convenience level, and overall satisfaction with digital learning experience.

Key Digitalization Aspect Perception

Analysis of how faculty and students understand and assess different educational digitalization aspects: from communication platforms to process automation, allowing identification of priorities and consensus among users (Table 9).

Table 9
Educational Digitalization Understanding by Process Participants

Digitalization Aspect	Academic Staff, %	Students, %	Consensus Level
Digital platforms for communication	86,1	88,2	Almost complete consensus
Administrative process automation	75,9	71,9	High
Electronic educational resources	74,1	70,8	High
Online courses and distance learning	72,3	68,0	High

Results demonstrate extraordinarily high consensus between academic staff and students regarding key educational digitalization aspects. Highest agreement level achieved in understanding digital platform role for communication, indicating fundamental educational paradigm change - from one-way knowledge transmission to interactive engagement. High support for administrative process automation (75,9% academic staff and 71,9% students) shows understanding of technology potential for routine operation optimization. Minor differences between groups (within 2-4%) indicate general educational community readiness for digital transformation and shared vision of its priority directions.

System Change Support

Assessment of educational process participant readiness for systematic digitalization changes, particularly attitudes toward platform standardization and creating unified digital solutions for universities (Table 10).

Table 10
Attitudes Toward Standardization and System Solutions

System Solution	Support, %	Indifferent, %	Against, %
Unified platform for learning	67,7	22,4	9,9
Unified platform for administration	66,3	30,5	3,2

User satisfaction is characterized by high digital technology acceptance. Highest consensus achieved regarding communication function, indicating educational paradigm change. Broad standardization support (67,7%) creates foundation for systematic changes.

Integrated Conclusions

Conducted analysis of five digital learning quality components allows forming a comprehensive picture of digitalization state in Ukrainian higher education. Each component demonstrates specific features and development levels, which together determine overall digital learning experience quality.

Research results indicate heterogeneous development of different quality aspects: some components show high results and readiness for further development, while others require immediate attention and systematic interventions. Such differentiation allows identifying priority improvement directions and optimal resource allocation.

Particularly important is identifying component interconnections: technological limitations affect pedagogical effectiveness, organizational maturity deficiencies hinder professional staff development, and all this together forms user satisfaction level. Understanding these interdependencies is key for developing effective digital learning quality improvement strategies.

Table 11
Summary Assessment of Digital Learning Quality Components

Quality Component	Key Indicators	Assessment	Development Priority
Technological Readiness	MOODLE (0,80), Zoom (0,87), AI (0,70)	Satisfactory	High
	Modern equipment (34,6%)	Critical	
Organizational Maturity	Strategy knowledge (44,4%)	Medium	High
	Primary e-document flow (14,5%)	Low	
Pedagogical Effectiveness	Hybrid support (94,2%)	Good	Medium
	Digital material use (63,9%)	Good	
Professional Staff Readiness	Basic training (84,9%)	Satisfactory	High
	Modern tools (44%)	Critical	
User Satisfaction	Communication consensus (87,2%)	Good	Low
	Standardization support (67,7%)	Good	

Key Trends and Challenges

Positive trends include successful basic technology adaptation with high MOODLE and Zoom usage indices, rapid innovative tool adoption including AI technologies, cultural readiness for change with broad hybrid learning support, and systematicity demand through platform standardization support.

Critical challenges remain technological gap between academic buildings and dormitories, faculty competency gap in modern digital tools, strategic uncertainty through low development strategy awareness, and organizational fragmentation of digitalization processes.

5. Conclusion

The conducted research confirmed effectiveness of the proposed comprehensive multidimensional model for evaluating digital learning quality, including five interconnected components. Empirical analysis of 17 Ukrainian universities with a sample of 344 respondents revealed significant heterogeneity in different digital learning quality aspect development, confirming the need for a systematic approach to educational digital transformation assessment and management.

Technological readiness analysis showed successful basic digital platform implementation (MOODLE - 80%, Zoom - 87%) and rapid adaptation to innovative technologies, including AI tools (70%). However, critical problems with technical infrastructure were identified: only 34,6% modern equipment and significant gap in internet connection quality between academic buildings (43% good) and dormitories (32%).

Organizational maturity demonstrates lowest indicators among all components. Critically low electronic document flow level (14,5% as primary) combines with insufficient strategic awareness - only 44-45% of educational process participants know about their institution's digital development strategy existence. This creates risks of fragmented digital solution implementation and reduces systematic transformation effectiveness.

Pedagogical effectiveness is characterized by broad hybrid learning support (94,2% respondents) and active academic staff digital material use (63,9% regularly). Differentiated attitudes toward digital technology application for different class types are observed: highest support for lectures (83,7%) and

lowest for laboratory work, where significant discrepancy exists between academic staff (17,5%) and student (37,6%) assessments.

Professional staff readiness demonstrates a paradoxical situation: high basic training provision level (84,9%) contrasts with critical deficit in modern digital tool training (44%). Every fourth academic staff member (26,5%) needs additional training, creating barriers for effective innovative pedagogical technology implementation.

User satisfaction shows highest results, especially in communication technology sphere (87,2% consensus between academic staff and students). Broad platform standardization support (67,7%) indicates systematic demand and readiness for digital learning approach unification.

Empirical research results reveal the interdependence of all five components of the model. In particular, successful digital transformation cannot be achieved without concurrent development of technological infrastructure, organizational support, instructor pedagogical proficiency, and high user satisfaction levels. The model's systemic character underscores the need for a holistic approach to digital learning quality management, wherein enhancement of one component positively influences others, generating a synergistic effect. The model's validity has been confirmed through expert assessment by professionals in digital education, which testifies to its applicability to digital transformation practices in Ukrainian universities.

Practical significance of the developed model lies in creating scientifically grounded tools for diagnosing, monitoring, and managing digital learning quality. The model can be used as a basis for educational institution self-assessment, digital transformation strategy formation, and resource allocation for improving weakest components.

Declaration on Generative AI

During the preparation of this work, the authors used Claude AI in order to: Grammar and spelling check. After using this service, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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