Future of Work and Digital Management Journal

Article type:
Original Research

Article history:
Received 06 October 2024
Revised 01 February 2025
Accepted 07 February 2025
Published online 30 July 2025

Identification and Validation of Factors Influencing Digital Transformation in Higher Education

Saeid. Khorami [1], Seyyed Abdollah. Amin Mousavi [2*], Mohammadreza. Sanaei [1]

1 Department of Information Technology Management, Qa.C., Islamic Azad University, Qazvin, Iran
2 Department of Industrial Management, CT.C., Islamic Azad University, Tehran, Iran

Corresponding author email address:
saa.mousavi@iau.ac.ir

How to cite this article:
Khorami, S., Amin Mousavi, S. A., & Sanaei, M. (2025). Identification and Validation of Factors Influencing Digital Transformation in Higher Education. *Future of Work and Digital Management Journal,* *3*(3), 1-11. https://doi.org/10.61838/10.61838/fwdmj.85

ABSTRACT

Digital transformation in higher education is one of the most significant contemporary issues, and identifying the factors influencing it can greatly contribute to the improvement of educational processes. This study was conducted with the aim of identifying and validating the factors influencing digital transformation in higher education. In the qualitative phase, through a systematic review of the literature and a detailed content analysis of Persian and English scientific articles extracted from reputable databases such as Scopus, ScienceDirect, Emerald, and Noor, the initial dimensions and components of a conceptual model for digital education based on artificial intelligence were identified and categorized. In the quantitative phase, in order to validate these factors and examine the structural relationships between them, the Interpretive Structural Modeling (ISM) technique was applied. The statistical population included university professors, educational managers, and postgraduate students in fields related to educational technology, educational management, education sciences, computer engineering, and artificial intelligence, who were selected through purposive and snowball sampling methods. A researcher-developed questionnaire was initially distributed among 30 participants, of which 22 valid questionnaires were ultimately analyzed. In data analysis, the adapted reachability matrix was first developed, and then the levels of factors were determined based on input and output relationships. The results indicated that criterion D7 was identified as the most fundamental factor, while criterion D5 emerged as the most dependent factor at the highest level, with other criteria positioned at intermediate levels. This hierarchical structure provided a clearer understanding of the role and importance of each factor in the digital transformation process, enabling prioritization and the design of targeted strategies. The findings serve as a valuable guide for higher education administrators and policymakers to accelerate and improve the digital transformation process.

Keywords: Digital Transformation, Higher Education, Digital University

Introduction

Digital transformation (DT) in higher education has emerged as one of the most critical developments in recent decades, reshaping not only instructional methodologies but also governance structures, administrative processes, and institutional sustainability strategies. The convergence of digital technologies such as artificial intelligence (AI), big data analytics, blockchain, and cloud computing has introduced both opportunities and challenges for universities worldwide, requiring holistic frameworks that address pedagogy, management, and societal impact simultaneously [1-3]. As higher education institutions (HEIs) move beyond digitization towards a deeper digital transformation, questions of efficiency, adaptability, and resilience dominate academic and policy discussions [4-6].

The concept of digital transformation goes far beyond the integration of digital tools in teaching. It refers to a systemic rethinking of how universities deliver value to students, faculty, and society. As Saxani and Dunkle [7] emphasize, leadership and organizational culture are pivotal in enabling such transformation. Without a shared vision and robust institutional governance, technology adoption risks remaining fragmented, leading to "islands of innovation" that fail to achieve broader institutional goals. Similarly, Alenezi [1] underscores the necessity of a maturity assessment framework to evaluate the progress of higher education institutions across various dimensions of digital transformation, from infrastructure to pedagogy.

The COVID-19 pandemic accelerated the urgency of digital transformation in HEIs, serving as both a catalyst and a stress test. During this period, institutions worldwide were compelled to transition rapidly to online education, exposing systemic vulnerabilities but also revealing new opportunities for resilience and global collaboration [8-10]. Studies of student experiences in the post-pandemic era highlight the dual demand for flexible digital infrastructures and personalized learning pathways that balance quality, accessibility, and engagement [8]. At the same time, higher education policymakers have acknowledged the importance of developing action plans at national and supranational levels to address digital equity and sustainability concerns [6, 10].

A growing body of literature reflects the multidimensionality of digital transformation in higher education. Research identifies both drivers and barriers, with institutional strategy, faculty readiness, financial investment, and technological infrastructure among the most frequently cited factors [11-13]. For example, Singun [11] emphasizes that institutional inertia and resistance to change remain significant barriers, while Gkrimpizi et al. [12] classify challenges into organizational, technical, and cultural categories. Furthermore, Sahni et al. [13] propose that the challenges in online teaching and learning environments can be structured into a comprehensive framework to guide both research and practice. The role of technology in fostering innovation within HEIs cannot be overstated. For example, Wang and Zhang [14] demonstrate that digital transformation enables sustainable innovation and enhances organizational performance by aligning technology adoption with environmental adaptation and dynamic organizational capabilities. Similarly, Zare et al. [15] argue that digital transformation can be strategically aligned with entrepreneurship and management to support broader institutional goals. This perspective situates digital transformation as not merely a technological upgrade but as a strategic imperative that redefines institutional missions and visions. Emerging technologies provide specific pathways for transformation. Blockchain, for instance, has been increasingly integrated into higher education for credential verification, secure data management, and academic integrity. Silaghi and Popescu [16] provide a systematic review demonstrating how blockchain-based initiatives compare to best practices, highlighting its potential to increase trust and efficiency in academic ecosystems. Likewise, AI-driven solutions such as chatbots, adaptive learning platforms, and predictive analytics are becoming prevalent in supporting both teaching and administrative tasks [17, 18]. Rahman et al. [17] find that students' adoption of AI chatbots is significantly influenced by technology readiness, pointing to the importance of digital literacy and user-centric design. Shavkat et al. [18] add that implementation mechanisms must focus on enhancing educational efficiency, ensuring that digital tools align with pedagogical objectives rather than functioning as mere add-ons.

The organizational dimension of digital transformation also demands attention. Mousavi and Shami Zanjani [19] stress the importance of adopting agile approaches to the digital transformation lifecycle, which enable institutions to adapt continuously to technological and environmental changes. Ferreira and Santos [20] further contextualize digital transformation within the broader public sector, identifying accountability and service enhancement as critical outcomes of digital innovation, which are equally applicable to higher education. Trevisan et al. [21] link digital transformation in higher education to sustainability objectives, demonstrating that digital strategies can contribute not only to institutional efficiency but also to global environmental and social goals.

In the academic library context, digital transformation has been particularly pronounced, given the shift toward digital repositories, data-driven services, and AI-enabled cataloguing. Khooeini et al. [22] identify components of transformation in academic libraries using a meta-synthesis method, concluding that libraries must evolve into digital knowledge hubs to remain relevant in the information ecosystem. These findings reinforce the notion that digital transformation is not confined to classroom teaching but permeates all dimensions of higher education institutions. Several policy reports and institutional strategies also highlight the systemic nature of digital transformation. The Educause Horizon Report [4] outlines emerging trends in teaching and learning, providing evidence that digital transformation requires continuous foresight and strategic planning. Similarly, the OECD [3] emphasizes a systemic approach, urging integration across pedagogy, governance, and technological infrastructure. National-level strategies, such as those documented by the Open University [5] and the World Bank [6], advocate for reimagining higher education through digital ecosystems that ensure equity, resilience, and global competitiveness. Tum [23] offers a strategic plan for a university-wide digital transformation, which serves as a concrete example of institutional-level commitment to these principles. The pedagogical implications of digital transformation are particularly significant. Digital universities, as conceptualized in recent scholarship, embody a new paradigm of higher education where learning is highly personalized, interactive, and globally networked [8, 24]. Rahimian [24] develops a grounded theory framework for designing digital universities, identifying essential dimensions such as pedagogy, infrastructure, governance, and student engagement. Chodak et al. [8] complement this by analyzing student experiences, revealing heightened expectations for flexibility, inclusivity, and digital literacy support. Together, these studies illustrate the co-evolution of institutional strategies and student needs in a digitalized academic environment.

Despite its potential, digital transformation also raises issues of risk management, sustainability, and long-term adaptation. Petrova et al. [25] highlight the strategic role of digital transformation in business development, an insight transferable to higher education given universities' dual role as educational and socio-economic institutions. Chodak et al. [8] and Deroncele-Acosta et al. [9] further argue that post-pandemic digital transformation must address not only efficiency but also equity and inclusivity, ensuring that all learners benefit from technological advances. The European Commission's [10] Digital Education Action Plan Progress Report underscores the necessity of ongoing monitoring and policy alignment to ensure that digital transformation contributes meaningfully to societal goals.

In summary, digital transformation in higher education is not a uniform process but a multifaceted paradigm shift that touches on governance, pedagogy, technology, and sustainability. As research demonstrates, successful digital transformation requires a comprehensive strategy that integrates leadership, infrastructure, policy, and stakeholder engagement [1-5, 7]. It demands agile frameworks [19], strategic control models [15], and a strong emphasis on student-centered design [8, 17]. As universities continue to navigate an uncertain global landscape shaped by technological, social, and environmental disruptions, digital transformation will remain central to their mission of fostering knowledge, innovation, and societal progress [16, 20, 21]. This aims to identify and validate the factors influencing digital transformation in higher education.

Methods and Materials

In this study, the factors influencing digital transformation in higher education were first identified through a systematic review of the literature and content analysis of scientific articles within a specified time frame (for both Persian and English articles). These articles were carefully collected from reputable scientific databases such as Scopus, ScienceDirect, Emerald, and Noor, and were examined based on inclusion criteria, relevance to the research topic, and scientific quality. Qualitative content analysis and meta-synthesis of study results led to the identification of the initial dimensions and components of a conceptual model for digital education based on artificial intelligence. These components were categorized into main and sub-concepts to provide a preliminary framework for subsequent analyses.

In the next stage, in order to validate these factors and measure the structural relationships among them, the quantitative phase of the study was conducted using the Interpretive Structural Modeling (ISM) technique. Based on the findings, in this stage, the statistical population included university professors, educational managers, and postgraduate students (master's and doctoral levels) in fields related to educational technology, educational management, educational sciences, computer engineering, and artificial intelligence. These individuals were required to have a relative or specialized understanding of artificial intelligence in higher education. To collect data, a researcher-developed questionnaire was used, and among the target population, 30 individuals were selected through purposive and snowball sampling. Ultimately, 22 valid questionnaires were collected and analyzed.

The inclusion criteria for the sample consisted of having academic or research experience in the field of digital education, familiarity with the foundations of artificial intelligence in education, and willingness and ability to provide accurate responses to specialized questions. This purposive selection was applied due to the specialized nature of the research topic, while snowball sampling was employed to identify qualified individuals in a community with limited accessibility to members. This approach made it possible to focus on the quality of responses and the accuracy of data analysis, thereby preparing the ground for structural analysis of the conceptual model's components.

Finally, the results derived from the ISM model, in addition to scientifically and empirically validating the identified factors, provided a hierarchical structure of the relationships among the components, enabling a more precise understanding of the influencing elements and their interactions in the digital transformation process of higher education.

Findings and Results

Table 1 presents a framework for establishing digital transformation in higher education, derived from the analysis of 66 articles. As shown, it encompasses 7 dimensions (AI-based advanced educational platforms, automated administrative processes, immersive learning environments, data-driven decision-making, sustainability and scalability, data privacy, and assessment and evaluation) and 33 categories.

Table 1. Dimensions and Categories of Digital Transformation in Higher Education

Dimension	Categories
AI-based Advanced Educational Platforms	- AI chatbots and virtual assistants
	- Personalized learning pathways
	- Intelligent learning systems
	- Virtual labs and simulations
Automated Administrative Processes	- Online admission and registration
	- Electronic tuition payment
	- Student welfare and health monitoring
	- Digital participation and certifications

Immersive Learning Environments	- Virtual reality (VR) and augmented reality (AR)
	- Interactive simulations
	- Virtual study groups
	- Global collaboration and cultural exchange
	- AI-driven classroom management
	- Access to global resources
Data-driven Decision Making	- Learning analytics
	- Data-driven decision support systems
	- Cybersecurity and data privacy
	- Predictive analytics
Sustainability and Scalability	- Cloud computing
	- Fraud detection
	- Energy-efficient technologies
Data Privacy	- Protection of sensitive data
	- Real-time threat detection
	- Blockchain-based data management
Assessment and Evaluation	- Automated classification and feedback
	- Intelligent task management
	- Fraud detection
	- Integrated academic evaluation

In the third step, the initial reachability matrix must be made compatible. This compatibility is achieved by adding secondary relationships, which may not exist initially, to the original reachability matrix. In Table 2, the cells marked with 1(**) represent relationships that were created in the compatible matrix.

Table 2. Compatible Initial Reachability Matrix

	D1	D2	D3	D4	D5	D6	D7	Driving Power
D1	1**	1	1	1	1**	1	1	7
D2	1*	1*	1	1**	1	1**	1	7
D3	1	1	1**	1	1**	1	1	7
D4	1	1**	1	1**	0	1	1	6
D5	1**	1	1	1**	1**	1**	1	7
D6	1	1**	1	1	0	1**	1	6
D7	0	0	0	0	0	0	1**	1
Dependence	6	6	6	6	4	6	7	

In the fourth step, the levels of each variable must be determined based on the compatible reachability matrix. The input, output, and intersection sets of variables are calculated. At each iteration, if the output set of a variable equals its intersection set, that iteration represents the i-th level. In the next iteration, the corresponding row and column of that variable are removed from the matrix, and the calculations are repeated. The results are presented below.

Table 3. Level 1 Criteria

Criterion	Output	Input	Intersection	Level
D1	D1D2D3D4D5D6D7	D1D2D3D4D5D6	D1D2D3D4D5D6	
D2	D1D2D3D4D5D6D7	D1D2D3D4D5D6	D1D2D3D4D5D6	
D3	D1D2D3D4D5D6D7	D1D2D3D4D5D6	D1D2D3D4D5D6	
D4	D1D2D3D4D6D7	D1D2D3D4D5D6	D1D2D3D4D6	
D5	D1D2D3D4D5D6D7	D1D2D3D5	D1D2D3D5	
D6	D1D2D3D4D6D7	D1D2D3D4D5D6	D1D2D3D4D6	
D7	D7	D1D2D3D4D5D6D7	D7	1

Table 4. Level 2 Criteria

Criterion	Output	Input	Intersection	Level
D1	D1D2D3D4D5D6	D1D2D3D4D5D6	D1D2D3D4D5D6	2
D2	D1D2D3D4D5D6	D1D2D3D4D5D6	D1D2D3D4D5D6	2
D3	D1D2D3D4D5D6	D1D2D3D4D5D6	D1D2D3D4D5D6	2
D4	D1D2D3D4D6	D1D2D3D4D5D6	D1D2D3D4D6	2
D5	D1D2D3D4D5D6	D1D2D3D5	D1D2D3D5	3
D6	D1D2D3D4D6	D1D2D3D4D5D6	D1D2D3D4D6	2

In the analysis of factor levels based on the compatible reachability matrix, the leveling process of criteria is performed such that at each stage, the criteria whose output sets exactly equal their intersection sets are identified as belonging to that level and then removed from the matrix. In Table (4), criterion D7 is the only criterion placed at the first level because both its output and intersection sets include only itself. After removing D7, the calculations for the remaining criteria D1 to D6 were performed, and the results are presented. At this stage, criteria D1, D2, D3, D4, and D6 were placed at the second level since their output and intersection sets were identical. After their removal, only D5 remained, which, due to the lack of equality between its output and intersection sets in the previous stage, was placed at the third level. These results indicate that D7 is the most fundamental criterion, whereas D5 has the highest dependence on other criteria and is positioned at the highest level. This analysis helps to understand the hierarchy of influence and dependency among criteria and can be used in designing decision-making models.

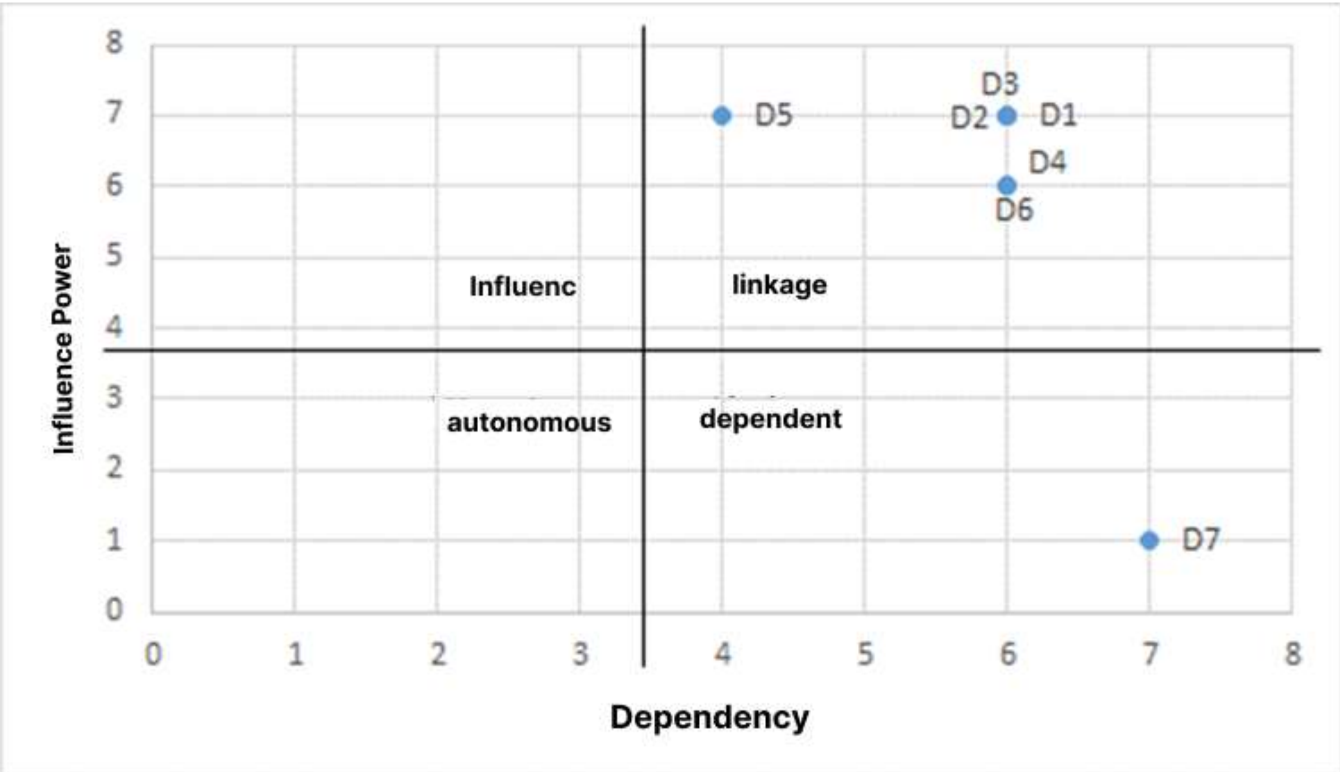

Figure 1. ISM Model of the Study

According to Figure (2), the research model includes three levels. The third level, which consists of the criterion of data-driven decision-making (D5), is the most influential level, directly affecting the five criteria of the second level. The criterion of automated administrative processes (D7), positioned at the first level, is the most dependent criterion.

Discussion and Conclusion

The findings of this study provide valuable insights into the identification and hierarchical structuring of factors influencing digital transformation in higher education. Through interpretive structural modeling (ISM), seven critical dimensions—AI-based advanced educational platforms, automated administrative processes, immersive learning environments, data-driven decision making, sustainability and scalability, data privacy, and assessment and evaluation—were identified and categorized across three hierarchical levels. The analysis revealed that data-driven decision making (D5) emerged as the most influential factor at the highest level, shaping other mid-tier dimensions, while automated administrative processes (D7) were identified as the most dependent element at the base of the structure. This outcome underscores the interplay between foundational administrative reforms and strategic data-driven governance in steering the trajectory of digital transformation in higher education.

The identification of data-driven decision making as the most influential dimension aligns with global trends in higher education governance and strategy. Universities increasingly rely on learning analytics, predictive modeling, and artificial intelligence to optimize both pedagogical and administrative decision-making processes [1, 17]. Previous frameworks for digital maturity assessment have emphasized the centrality of data management systems in facilitating evidence-based strategic decisions [1, 3]. This is consistent with the OECD's systemic approach, which considers data integration not only a technical requirement but also a governance imperative [3]. Similarly, Rahman et al. [17] found that students' adoption of AI-enabled systems, such as chatbots, depends significantly on their trust in data-driven processes, suggesting that decision making supported by analytics influences both institutional efficiency and student engagement. The present findings expand on this literature by demonstrating, through a structural modeling approach, that data-driven governance occupies the top tier in a hierarchical transformation model, exerting direct influence over other dimensions such as immersive learning and evaluation frameworks.

Automated administrative processes (D7), conversely, emerged as the most dependent factor, indicating that their effectiveness is shaped by higher-order variables such as data-driven governance and intelligent platforms. This is consistent with prior studies emphasizing that digital transformation in universities often begins with the automation of administrative tasks, such as admissions, tuition payments, and student support systems [9, 18, 23]. While automation can deliver immediate efficiency gains, its success is contingent on integrated data ecosystems and advanced platforms. The European Commission [10] similarly observed that administrative automation is one of the most visible but also most dependent layers of institutional digitalization. These observations validate the present study's conclusion that automation alone cannot serve as the foundation of transformation unless supported by systemic frameworks of governance and data integration.

The positioning of immersive learning environments in the intermediate layer of the hierarchy reflects their bridging role between data-driven governance and frontline teaching practices. Immersive technologies, such as virtual reality (VR), augmented reality (AR), and simulation platforms, have been increasingly studied as catalysts for enhancing student engagement and global collaboration [8, 24]. Studies conducted in the post-COVID era confirm that students expect flexible, interactive, and digitally enriched learning experiences that extend beyond traditional classrooms [8]. This study corroborates those findings by showing that immersive learning is not the ultimate driver of transformation but rather a mid-level factor influenced by institutional decision making and enabling platforms. In this sense, immersive learning constitutes an application-oriented outcome of higher-level policies and strategies, making it essential but not independent.

Another critical dimension identified in this study is sustainability and scalability, which plays a vital role in ensuring that digital transformation efforts remain viable over the long term. Trevisan et al. [21] highlight that digital strategies in higher education must align with broader sustainability goals, contributing not only to institutional efficiency but also to environmental and social responsibility. Cloud computing, energy-efficient technologies, and fraud detection mechanisms are examples of scalable solutions that sustain transformation. This study's results confirm the argument that without scalable infrastructures, digital transformation risks being fragmented or short-lived [14, 25]. The emphasis on sustainability also resonates with broader frameworks for organizational resilience in digital innovation, as discussed by Ferreira and Santos [20], who stress accountability and adaptability as hallmarks of sustainable transformation.

The hierarchical analysis also underscored the central role of data privacy and cybersecurity as non-negotiable prerequisites for transformation. The findings place data privacy as a mid-level factor, influencing both evaluation systems and immersive learning environments. This reflects the reality that breaches of trust in data management can undermine adoption rates and institutional credibility [16, 19]. Silaghi and Popescu [16] illustrate that blockchain-based initiatives have gained prominence as solutions for ensuring secure credentialing and student data protection, reinforcing the present study's conclusion that robust privacy safeguards underpin the sustainability of digital initiatives. Furthermore, studies in the broader public sector context, such as those by Ferreira and Santos [20], also note that privacy and accountability are mutually reinforcing pillars of digital innovation.

Assessment and evaluation, placed in the structural model as an intermediate criterion, highlight the role of intelligent feedback systems in improving learning outcomes and institutional accountability. Automated grading, intelligent task management, and integrated evaluation frameworks are increasingly seen as central to the digital university model [22, 24]. Khooeini et al. [22] emphasize that academic libraries, as knowledge hubs, are undergoing similar transformations by integrating evaluation systems based on AI and big data. These observations support the present study's conclusion that evaluation is not a peripheral activity but rather an integral dimension of transformation, situated between strategic governance and classroom-level application.

The study's findings also contribute to ongoing debates regarding barriers and challenges in digital transformation. While hierarchical modeling clarified the structural relationships between dimensions, several identified dependencies reflect widely recognized challenges in the literature. For example, Singun [11] identifies organizational inertia as a primary barrier, while Sahni et al. [13] highlight resistance to online teaching models. The fact that administrative automation (D7) emerged as highly dependent in this study reflects these systemic challenges, since automation is often hindered by resistance, inadequate infrastructure, or misalignment with strategic governance. Similarly, Gkrimpizi et al. [12] classify barriers into cultural, organizational, and technical dimensions, findings that are mirrored in the interdependencies revealed in this study's hierarchical structure.

From a strategic perspective, the findings underscore the necessity of aligning digital transformation with institutional missions and visions. Zare et al. [15] propose a strategic control model linking digital transformation with entrepreneurship and management, which resonates with this study's conclusion that strategic governance and decision making occupy the highest level in driving transformation. The OECD [3] and Educause [4] similarly call for systemic integration across governance, pedagogy, and infrastructure, affirming that isolated initiatives are insufficient. This systemic view is further supported by Tum [23], which illustrates through its strategic plan how transformation must be embedded across all functions of the university.

Collectively, these findings provide empirical validation for theoretical and policy frameworks that conceptualize digital transformation as a holistic and hierarchical process. The placement of data-driven governance at the top of the hierarchy, coupled with the dependency of automation at the base, illustrates the layered interdependencies that define the digital transformation journey. This nuanced understanding contributes to both scholarly and practical debates, offering guidance for policymakers, university leaders, and researchers seeking to navigate the complexities of transformation in higher education.

This study, while comprehensive in its identification and validation of digital transformation dimensions, is subject to certain limitations. The qualitative stage relied heavily on systematic reviews of published literature, which may have excluded relevant unpublished or context-specific studies. The quantitative stage involved purposive and snowball sampling, resulting in a relatively small sample size of experts, which may not fully represent the diversity of higher education systems worldwide. Additionally, the interpretive structural modeling technique, while useful for mapping interdependencies, is inherently reliant on expert judgments, which introduces subjectivity into the analysis. Finally, the hierarchical model, though insightful, may not capture the full dynamism of digital transformation processes, which evolve rapidly in response to technological and policy shifts.

Future research should aim to expand the scope of empirical validation by including larger and more diverse samples of higher education stakeholders, particularly across different cultural, economic, and institutional contexts. Comparative studies between developed and developing countries could shed light on how resource constraints and policy environments shape the hierarchy of transformation dimensions. Longitudinal research designs would also provide valuable insights into how digital transformation evolves over time, particularly in response to disruptive events such as pandemics or technological breakthroughs. Furthermore, future studies could integrate advanced quantitative methods, such as structural equation modeling (SEM) or machine learning, to triangulate findings from ISM and enhance robustness. Finally, research should also examine student perspectives in greater depth, ensuring that their expectations and experiences inform institutional strategies for digital transformation.

For practitioners, the findings highlight the importance of prioritizing data-driven decision making as the strategic anchor of digital transformation efforts. University leaders should focus on building robust data ecosystems and analytics capacities before scaling immersive learning environments or automated administrative systems. Ensuring sustainability and scalability should remain a central concern, with investments directed toward cloud computing, secure infrastructures, and environmentally responsible technologies. Policies should also place strong emphasis on data privacy and cybersecurity to build trust among students, faculty, and stakeholders. Finally, institutions should adopt agile and adaptive governance models that enable iterative learning and responsiveness, ensuring that transformation strategies remain aligned with rapidly changing technological landscapes and societal needs.

Acknowledgments

We would like to express our appreciation and gratitude to all those who cooperated in carrying out this study.

Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

References

[1] M. Alenezi, "Digital Transformation in Higher Education: A Framework for Maturity Assessment," *International Journal of Emerging Technologies in Learning,* vol. 16, no. 5, pp. 4-21, 2021.

[2] M. Brown, B. Reinitz, and K. Wetzel. "Digital transformation signals: Is your institution on the journey." https://er.educause.edu/blogs/2019/10/digital-transformation-signals-is-your-institution-on-the-journey (accessed.

[3] Oecd, "Digital Transformation in Education: A Systemic Approach," 2021.

[4] Educause, "2022 Horizon Report: Teaching and Learning Edition," 2022.

[5] U. Open, "Digital Strategy 2021-2025," 2021.

[6] B. World, "Reimagining Higher Education: Digital Transformation in Asia," 2021.

[7] V. Saxani and D. Dunkle, "Digital Transformation in Higher Education: The Role of Leadership and Organizational Culture," *Journal of Information Technology Case and Application Research,* vol. 21, no. 3, pp. 123-142, 2019.

[8] K. Chodak *et al.*, "Digital University: A Study of Students' Experiences and Expectations in the Post-COVID Era," *Education Sciences,* vol. 13, no. 2, p. 219, 2023, doi: 10.3390/educsci13020219.

[9] A. Deroncele-Acosta, M. L. Palacios-Núñez, and A. Toribio-López, "Digital Transformation and Technological Innovation on Higher Education Post-COVID-19," *Sustainability,* vol. 15, no. 3, p. 2466, 2023, doi: 10.3390/su15032466.

[10] C. European, "Digital Education Action Plan Progress Report," 2023.

[11] A. J. Singun, "Unveiling the barriers to digital transformation in higher education institutions: a systematic literature review," *Discover Education,* vol. 4, no. 1, p. 37, 2025, doi: 10.1007/s44217-025-00430-9.

[12] T. Gkrimpizi, V. Peristeras, and I. Magnisalis, "Classification of Barriers to Digital Transformation in Higher Education Institutions: Systematic Literature Review," *Education Sciences,* vol. 13, no. 7, p. 746, 2023, doi: 10.3390/educsci13070746.

[13] S. Sahni, S. Verma, and R. P. S. Kaurav, "Understanding digital transformation challenges for online learning and teaching in higher education institutions: a review and research framework," *Benchmarking: An International Journal,* vol. 32, no. 5, pp. 1487-1521, 2025, doi: 10.1108/BIJ-04-2022-0245.

[14] S. Wang and H. Zhang, "Enhancing SMEs sustainable innovation and performance through digital transformation: Insights from strategic technology, organizational dynamics, and environmental adaptation," *Socio-Economic Planning Sciences,* vol. 98, p. 102124, 2025, doi: 10.1016/j.seps.2024.102124.

[15] R. Zare, M. Abedian Khorasani, V. Khashei, and M. Haghighi Kafash, "Strategic Control Model Based on Digital Transformation, Technology in Entrepreneurship, and Strategic Management," 2025.

[16] D. L. Silaghi and D. E. Popescu, "A Systematic Review of Blockchain-Based Initiatives in Comparison to Best Practices Used in Higher Education Institutions," *Computers,* vol. 14, no. 4, p. 141, 2025, doi: 10.3390/computers14040141.

[17] M. K. Rahman, M. A. Hossain, N. A. Ismail, M. S. Hossen, and M. Sultana, "Determinants of students' adoption of AI chatbots in higher education: the moderating role of tech readiness," *Interactive Technology and Smart Education,* 2025, doi: 10.1108/ITSE-12-2024-0312.

[18] A. Shavkat, A. Kural, and Y. Maryam, "THE IMPLEMENTATION MECHANISM OF DIGITAL TRANSFORMATION TO ENHANCE EDUCATIONAL EFFICIENCY IN HIGHER EDUCATION INSTITUTIONS," *Advanced methods of ensuring the quality of education: problems and solutions,* vol. 2, no. 4, pp. 93-97, 2025.

[19] A. M. Mousavi and M. Shami Zanjani, "Agile Digital Transformation Lifecycle: A Systematic Literature Review," *Organizational Culture Management,* vol. 23, no. 2, pp. 225-241, 2025.

[20] A. Ferreira and C. Santos, "Digital Transformation in Public Sector: Systematic Literature Review," in *Enhancing Public Sector Accountability and Services Through Digital Innovation*, 2025, pp. 265-288.

[21] L. V. Trevisan, J. H. P. P. Eustachio, B. G. Dias, W. L. Filho, and E. Á. Pedrozo, "Digital transformation towards sustainability in higher education: state-of-the-art and future research insights," *Environment, Development and Sustainability,* 2023, doi: 10.1007/s10668-022-02874-7.

[22] S. Khooeini, A. Norouzi, N. Naghshineh, and F. Sheikh Shoaei, "Identifying the Components of Digital Transformation in Academic Libraries Using the Meta-Synthesis Method," *Library and Information Science,* vol. 26, no. 2, pp. 156-186, 2023.

[23] Tum, "Digital TUM: Strategic Plan for the Digital Transformation of the University," 2022.

[24] A. Rahimian, "Designing a Conceptual Framework for a Digital University: A Grounded Theory Approach," *Research and Planning in Higher Education,* vol. 29, no. 2, pp. 69-86, 2023, doi: 10.61838/irphe.29.2.4.

[25] L. A. Petrova, S. U. Niyazbekova, T. E. Kuznetsova, S. B. Sarbassova, and K. I. Baymukhametova, "Digital transformation as a strategic direction business development in modern conditions," in *Cooperation and Sustainable Development*, 2022, pp. 183-192.