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Designing a Sustainable Digital Transformation Model in Iranian Higher Education: A Mixed-Methods Study

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ABSTRACT

In today's world, universities—as scientific and cultural institutions—play a central role in moving societies toward sustainable development. At the same time, digital transformation has become an inevitable necessity that affects all dimensions of academic activities. The present study was conducted with the aim of designing a digital transformation model for higher education based on a sustainable development approach. This research employed an exploratory mixed-methods design implemented in three sequential phases. In the qualitative phase, interviews were conducted with 20 experts, and the data were analyzed using the grounded theory method. In the intermediate phase, the initial model was validated using the fuzzy Delphi technique with 15 experts. In the quantitative phase, the final model was tested with 300 managers and faculty members from universities in Kerman Province using structural equation modeling in SmartPLS software. The data analysis resulted in the development of a model comprising six main dimensions and eighteen components. The main dimensions included sustainable technological, integrated managerial, cultural–human, educational–research, multidimensional sustainability, and localization. Model fit indices indicated desirable goodness-of-fit (CFI = 0.93, RMSEA = 0.06). The interactive effect of digital transformation and sustainable development on educational quality (path coefficient = 0.52) and scientific productivity (path coefficient = 0.45) was significant and strong. The proposed model provides an indigenous and practical framework for Iranian universities, demonstrating that digital transformation and sustainable development are two sides of the same coin, and their simultaneous pursuit leads to improved educational quality and enhanced scientific productivity.

Keywords: Digital transformation, higher education, sustainable development, structural equation modeling, fuzzy Delphi.

Introduction

The rapid acceleration of digital transformation has reshaped every aspect of higher education worldwide, positioning universities at the center of structural, technological, and pedagogical change. As higher education institutions (HEIs) confront the combined pressures of globalization, sustainability imperatives, and disruptive technologies, the need for integrated, strategic, and sustainable digital transformation has become more urgent than ever. Digital transformation, once viewed merely as the adoption of technological tools, has evolved into a multidimensional organizational shift that encompasses governance, culture, pedagogy, human capital, and institutional sustainability (1). In this context, universities must not only upgrade their digital infrastructures but also



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cultivate a governance system capable of managing complexity, uncertainty, and continuous innovation (2). The interplay between digital transformation and sustainable development is now recognized as a central determinant of institutional resilience, competitiveness, and long-term societal contribution (3).

The global landscape of higher education reflects a rapidly widening digital divide, particularly among universities in developing or transitioning economies. UNESCO's global report highlights that digital transformation is unevenly distributed, shaped by disparities in resources, governance, regulation, and digital readiness (4). Many institutions struggle to integrate digital systems into their pedagogical processes, while others face systemic limitations such as outdated infrastructure, financial constraints, and resistance to organizational change. These challenges are not only technical but deeply structural, affecting institutional culture, leadership, and stakeholder engagement. The need for sustainability-centered digital transformation is therefore a global priority, as universities increasingly align their digital strategies with environmental stewardship, social responsibility, and long-term resilience (5).

Digital governance has emerged as one of the most decisive dimensions shaping successful transformation in higher education. Zhang and Li emphasize that digital governance operates at the intersection of policy, data management, leadership, and digital ethics, demanding cohesive frameworks capable of guiding institutions through change (2). Effective digital governance ensures not only the adoption of technology but the harmonization of systems, processes, and human competencies. Studies show that without strong digital governance, universities face fragmentation, redundancy, and inefficiency in their digital initiatives (6). These issues are often exacerbated in traditional or bureaucratic institutions where hierarchical structures impede agile decision-making and inhibit innovation (7). Resistance to change remains a pervasive challenge; many stakeholders feel threatened by technological shifts that require new competencies, reconceptualization of traditional roles, and transformations in teaching, assessment, and research processes.

The expanding role of artificial intelligence (AI) further complicates these dynamics, introducing questions of ethics, transparency, and sustainability. Taylor and colleagues note that AI is increasingly used to enhance personalized learning, predictive analytics, learning management systems, and resource efficiency, yet its adoption demands careful alignment with sustainability frameworks and institutional values (8). Similarly, Muhabbat et al. argue that AI-enabled systems in university management can significantly improve efficiency, predictive planning, and decision-making, but they require leadership capable of understanding both technological opportunities and ethical risks (9). This fusion of AI and governance positions universities at a pivotal moment, where digital transformation is not only technical but strategic and moral.

Leadership is consistently identified as a determining factor in digital transformation outcomes. Niţă and Guțu show that leadership plays a crucial role in fostering student engagement, organizational learning, and digital innovation, emphasizing the need for leaders who champion digital culture and model adaptive behaviors (10). In Iranian universities, research shows persistent leadership-related barriers, including insufficient digital literacy among managers, fragmented planning systems, and limited familiarity with sustainability frameworks (11). These leadership challenges interact with structural constraints such as limited funding, outdated technologies, and inadequate stakeholder participation, creating a complex environment for transformation (12). Therefore, understanding the cultural, organizational, and policy-related dimensions of leadership is critical for designing effective models of digital transformation.

International literature suggests that digital transformation is inseparable from sustainability. Trevisan and colleagues emphasize that universities must integrate sustainability principles—economic, social, cultural, and

environmental—within their digital strategies to remain relevant and responsible in the twenty-first century (3). Chen and colleagues similarly argue that European universities have made progress by directly linking digital transformation to sustainability goals, particularly in the areas of energy efficiency, digital equity, waste reduction, and green campus initiatives (13). The incorporation of sustainability into digital strategy helps universities balance innovation with responsibility, ensuring that technological growth does not contribute to social exclusion or environmental degradation.

The cultural dimension of digital transformation is increasingly acknowledged in contemporary scholarship. Organizational culture influences digital readiness, technology adoption, and innovation capacity. Brown and Lee argue that universities must shift towards cultures of collaboration, creativity, agility, and openness to experimentation if they are to thrive in the digital era (14). Resistance to change, however, remains widespread, especially in traditional universities where faculty and administrators may feel uncertain about their roles within new digital systems (7). Studies demonstrate that digital competence among faculty and students is a fundamental prerequisite for successful transformation, as digital literacy directly influences engagement, instructional effectiveness, and institutional performance (15).

Pedagogical transformation is another critical aspect, requiring innovation in teaching methodologies, curriculum design, and assessment systems. Ma and Ruannakarn show how digital technologies—particularly Internet+ systems—enhance learning performance and engagement by enabling interactive and personalized learning pathways (16). In addition, Bezi and colleagues highlight the importance of embedding environmental and sustainability principles into curriculum design to ensure that higher education responds to contemporary ecological challenges (17). Integrating sustainability into digital pedagogy allows universities to prepare graduates with both the technological and ethical competencies needed for modern societal demands.

Research on digital barriers provides further insight into the challenges universities face. Krimpizi and colleagues provide a systematic classification of barriers, including technological, logistical, human, financial, and regulatory constraints (6). Singun's systematic review identifies overlapping barriers such as lack of strategic planning, limited digital skills, insufficient funding, and institutional resistance (18). Sahni et al. expand on these barriers in the context of online learning, pointing out that the transition to digital modalities revealed weaknesses in digital pedagogy, faculty readiness, and technological infrastructure across many HEIs (19). These findings indicate that digital transformation is a holistic institutional process that requires addressing internal and external factors simultaneously.

The role of stakeholders—including students, faculty, administrators, policymakers, and technology providers—is also crucial. Gull and colleagues emphasize that resilient higher education institutions depend heavily on collaborative governance, technological capacity, and stakeholder participation to sustain digital transformation efforts (20). Gutiérrez and colleagues similarly argue that strategic alignment between internal stakeholders and institutional goals is a key driver of digital maturity (15). A lack of stakeholder engagement, on the other hand, often leads to fragmented, inconsistent, or ineffective transformation initiatives (21). Thus, building a shared vision is essential.

In Iran, the digital transformation landscape reflects both significant progress and persistent structural challenges. Although national policies emphasize digital modernization, universities face barriers such as bureaucratic inefficiencies, outdated infrastructures, limited budgets, and insufficient stakeholder involvement (12). Studies show that Iranian universities require comprehensive frameworks that integrate digital transformation with

sustainability principles and local contextual needs (22). Furthermore, future studies methodologies—such as horizon scanning, scenario development, and trend analysis—have gained traction in Iranian academic planning, emphasizing the need for anticipatory governance capable of responding to technological and societal changes (23). Integrating futures studies into digital transformation ensures that universities remain resilient and adaptive in rapidly changing environments.

Marketing and strategic planning perspectives also offer useful insights. Koyuncuoglu argues that digital transformation in higher education increasingly aligns with omnichannel frameworks, emphasizing personalized digital experiences and multi-platform engagement for students (24). Santos and Cruz highlight the growing interface between multidisciplinary learning and digital transformation, emphasizing that digital ecosystems can bridge educational sectors and improve learning outcomes (5). These ideas reinforce the need for holistic, integrated digital transformation models capable of addressing diverse institutional functions including education, research, administration, communication, and community engagement.

Furthermore, the global movement toward sustainable development goals (SDGs) underscores the necessity of aligning higher education transformation with environmental, social, and economic sustainability. Taylor and colleagues demonstrate how universities across the world use AI and digital tools to support SDGs, from reducing carbon footprints to improving digital equity in underserved populations (8). Babalola and Genga also show that African universities face similar challenges related to digital readiness, equity, and sustainable integration of digital technologies, highlighting the importance of capacity building and policy reform (25). Collectively, these studies underscore the universal need for coherent and context-sensitive frameworks guiding sustainable digital transformation.

Taken together, the literature reveals several converging insights. Digital transformation is no longer a purely technological process but a strategic, cultural, sustainability-oriented, and governance-dependent phenomenon shaping the future of higher education. Universities must integrate digital capabilities with sustainable development principles, engage diverse stakeholders, cultivate digital leadership, and address systemic barriers to effectively navigate the complexities of the digital era. Despite increasing scholarly attention, there remains a gap in comprehensive models tailored to the cultural, organizational, and infrastructural realities of Iranian higher education.

The aim of this study is to design a sustainable digital transformation model for Iranian higher education using a mixed-methods approach.

Methods and Materials

The methods and materials for this study were developed within an exploratory mixed-methods framework in which qualitative inquiry, expert validation, and quantitative testing were integrated across three interconnected phases. In the first phase, a qualitative exploratory design was employed to identify and conceptualize the core components of sustainable digital transformation in Iranian higher education. Participants for this phase consisted of twenty experts in the higher education sector who were selected through purposive sampling using a snowball technique to ensure access to individuals with substantial experience in digital transformation and sustainable development initiatives. The criteria for expert inclusion required a minimum of fifteen years of managerial or academic experience in higher education, a record of scientific publications related to digital transformation or sustainability, and direct involvement in relevant strategic or operational projects. Data collection was conducted

through semi-structured interviews that allowed flexible yet systematic exploration of participants' insights. All interviews were transcribed and analyzed using the grounded theory approach, following three stages of coding—open, axial, and selective. MAXQDA software facilitated the organization, categorization, and integration of codes, enabling the emergence of a coherent preliminary framework for the model.

The second phase of the study involved the design and validation of the preliminary model using expert consensus. Fifteen specialists in digital transformation, higher education management, sustainability studies, and educational technology participated in this phase. Data were collected using a fuzzy Delphi questionnaire that captured expert judgments with greater precision by incorporating linguistic variables and fuzzy number computations. The fuzzy Delphi process was conducted across three iterative rounds, during which experts reviewed, refined, and rated the importance and coherence of the model components derived from the qualitative phase. The iterative process continued until the predefined stopping criterion—achievement of a consensus coefficient greater than 0.7—was met. At the end of this phase, the initial framework was refined into a validated preliminary model suitable for quantitative testing.

The third phase focused on empirically testing the final model through a quantitative survey. The research design in this phase followed a descriptive-survey and correlational approach aimed at assessing the structural relationships among the identified components of sustainable digital transformation. The statistical population included faculty members from public and private universities across Kerman Province, as well as educational and administrative managers and specialists in educational information technology, totaling approximately five hundred individuals. A sample of three hundred participants was determined using Cochran's formula to ensure sufficient statistical power and generalizability. Stratified random sampling proportional to population size was employed to ensure adequate representation of different universities, academic ranks, and managerial positions. Data collection in this phase was conducted through a researcher-developed questionnaire consisting of four sections aligned with the major dimensions identified during the qualitative and Delphi phases. Content validity was established through expert review, and the instrument demonstrated high reliability with a Cronbach's alpha coefficient of 0.89. The data were analyzed using structural equation modeling to evaluate the measurement and structural components of the model. SmartPLS software was used to test factor loadings, construct validity, path coefficients, and model fit indicators, which enabled rigorous assessment of the model's empirical adequacy and the strength of relationships among its latent variables.

Findings and Results

The findings of the study consist of two major components: qualitative insights derived from grounded theory analysis and quantitative results obtained from survey data and structural equation modeling. The qualitative phase enabled the identification of core components and processes related to sustainable digital transformation in higher education, while the quantitative phase empirically validated the proposed model using data from 300 academic and managerial participants.

Table 1. Extracted Concepts from Open Coding

No.	Concept	Sample Codes
1	Sustainable technological infrastructure	Low-energy servers, green data centers
2	Digital governance	Integrated policymaking, data-driven decisions
3	Transformative organizational culture	Change acceptance, creativity and innovation
4	Digital competencies	IT skills, digital literacy

5	Strategic planning	Roadmap development, strategy alignment
6	Financial resources and investment	Dedicated budgeting, external investment

The first table shows that open coding produced 156 initial codes grouped into 18 main concepts. These concepts reveal that experts emphasized technological readiness, governance structures, organizational culture, professional competencies, strategic planning, and financial capacity as critical factors shaping sustainable digital transformation.

Table 2. Categorization of Concepts into Axial Categories

Axial Category	Related Concepts
Technological dimension	Sustainable infrastructure, data management, cybersecurity
Managerial dimension	Digital governance, strategic planning, financial resources
Cultural–human dimension	Organizational culture, digital competencies, social responsibility
Educational–research dimension	Educational innovation, stakeholder participation, digital equity
Sustainability dimension	Economic sustainability, social sustainability, environmental sustainability
Localization dimension	Local requirements, regulations and policies

As shown in Table 2, axial coding organized the initial concepts into six major categories: technological, managerial, cultural–human, educational–research, sustainability, and localization. These categories demonstrate the multidimensional nature of sustainable digital transformation and show how multiple organizational layers interact to shape transformation outcomes.

Through selective coding, the core category of the research—integrated digital transformation with a sustainable development approach in higher education—was identified. The paradigm model was built accordingly, capturing causal conditions, the central phenomenon, intervening conditions, strategies, contextual conditions, and final outcomes, ultimately showing how sustainable digital transformation leads to smart, future-oriented, and quality-driven universities.

Table 3. Descriptive Indicators of Research Variables

Variable	Mean	SD
Technological infrastructure	3.45	0.89
Digital governance	2.89	0.95
Digital competencies	3.12	0.87
Economic sustainability	3.25	0.92
Social sustainability	2.95	0.98
Environmental sustainability	3.08	0.84
Educational quality	3.78	0.76
Scientific productivity	3.52	0.82

Table 3 provides descriptive statistics for the quantitative phase. Educational quality had the highest mean score (3.78), indicating relatively strong performance in instructional outcomes. Digital governance had the lowest mean score (2.89), reflecting weaknesses in managerial and policy structures. The technological infrastructure score (3.45) suggests moderate readiness, while environmental sustainability (3.08) and economic sustainability (3.25) show partial progress in sustainability initiatives.

Table 4. Fit Indices of the Measurement Model

Fit Index	Value	Acceptable Threshold	Interpretation
χ^2/df	2.34	< 3	Acceptable
CFI	0.93	> 0.90	Good
GFI	0.91	> 0.90	Good
RMSEA	0.06	< 0.08	Good
SRMR	0.05	< 0.08	Good

As shown in Table 4, all measurement model indices fall within desirable ranges. High values for CFI (0.93) and GFI (0.91) reflect strong absolute fit, while RMSEA (0.06) and SRMR (0.05) confirm that residuals are minimal, supporting the overall accuracy of the measurement model.

Table 5. Construct Validity and Reliability Indicators

Construct	AVE	CR	Cronbach's α
Digital transformation	0.68	0.91	0.89
Sustainable development	0.65	0.88	0.86
Educational quality	0.62	0.85	0.83
Scientific productivity	0.59	0.82	0.80

Table 5 confirms that all constructs have AVE values above 0.50, demonstrating strong convergent validity. Both composite reliability and Cronbach's alpha exceed 0.80 for all constructs, indicating high internal consistency and confirming the robustness of the measurement instruments.

Table 6. Results of Hypothesis Testing

Hypothesis	Path	Path Coefficient	t-value	p-value	Result
H1	Digital transformation → Educational quality	0.45	6.78	0.000	Supported
H2	Sustainable development → Educational quality	0.38	5.92	0.000	Supported
H3	Digital transformation → Scientific productivity	0.41	6.15	0.000	Supported
H4	Sustainable development → Scientific productivity	0.35	5.43	0.000	Supported
H5	Interaction of DT and SD → Outcomes	0.52	7.89	0.000	Supported

The results in Table 6 show that all hypotheses were strongly supported. Digital transformation significantly improved both educational quality (0.45) and scientific productivity (0.41). Sustainable development also had meaningful positive effects on both outcomes. The interaction term (0.52) had the strongest effect, indicating that digital transformation and sustainable development mutually reinforce one another when implemented simultaneously.

Table 7. Fit Indices of the Final Structural Model

Index	Value	Acceptable Threshold	Status
R^2 Educational quality	0.67	> 0.33	Strong
R^2 Scientific productivity	0.59	> 0.33	Moderate–Strong
Q^2 Educational quality	0.45	> 0.35	Strong
Q^2 Scientific productivity	0.38	> 0.35	Acceptable

According to Table 7, the structural model demonstrates high explanatory power, with 67% of the variance in educational quality and 59% of the variance in scientific productivity explained by the model. Predictive relevance indices (Q^2) are also positive and above threshold values, confirming the model's predictive accuracy. Additional analyses revealed significant differences across universities in technological infrastructure, digital governance, and environmental sustainability ($p < .05$), whereas educational quality and scientific productivity did not differ significantly. Correlation results showed strong positive relationships between digital transformation and educational quality (0.72), as well as between sustainable development and organizational sustainability (0.71), reinforcing the theoretical and empirical coherence of the proposed model.

Discussion and Conclusion

The results of the present study provide a comprehensive understanding of how sustainable digital transformation operates within higher education institutions and how its dimensions influence educational quality

and scientific productivity. The qualitative phase revealed six major dimensions—technological, managerial, cultural–human, educational–research, sustainability, and localization—indicating that digital transformation is a multidimensional institutional process rather than a purely technological upgrade. This aligns with global conceptualizations of digital transformation, which position universities as socio-technical ecosystems rather than technology-driven organizations (1). The emphasis that participants placed on sustainable infrastructure, governance, digital competencies, and organizational culture echoes global policy frameworks that identify these elements as foundational to systemic digital change (4). The emergence of sustainability as a central axis within the model further demonstrates that digital transformation and sustainable development are increasingly inseparable in contemporary higher education strategies (3).

Quantitative results confirmed that both digital transformation and sustainable development have significant positive effects on educational quality and scientific productivity. The strong effect of digital transformation on educational quality corresponds with existing scholarship that demonstrates how digital tools, data analytics, and digital pedagogies enhance engagement, personalization, and learning effectiveness (14). Similarly, studies on Internet+ systems and AI-enabled educational technologies support the conclusion that digitally enriched learning environments improve instructional quality and academic performance (8, 16). The significant pathway between digital transformation and scientific productivity is consistent with evidence that technological infrastructure, research data platforms, and digital collaboration tools directly influence knowledge creation and research outputs (15).

The positive effect of sustainable development on both educational quality and productivity reinforces the growing argument that sustainability is not an external add-on to institutional functioning but a structural principle that shapes governance, resource allocation, educational design, and research priorities (13). Universities that incorporate sustainability into their strategies—through green infrastructures, responsible resource management, curriculum transformation, and inclusive digital access—tend to achieve better long-term academic outcomes and higher institutional resilience (20). This finding also supports earlier Iranian studies identifying that sustainability-oriented strategic planning is critical for improving performance and mitigating environmental and organizational risks (11).

One of the most notable findings of the study is the strong interaction effect between digital transformation and sustainable development. The synergy between these two constructs indicates that sustainability strengthens the implementation of digital systems, while digital transformation enhances the operationalization of sustainability initiatives. This bidirectional reinforcement mirrors the global trend in which universities increasingly use digital systems for energy optimization, inclusive access, green campus management, and data-driven sustainability reporting (8). Conversely, sustainability frameworks encourage universities to adopt digital technologies in ways that are ethical, responsible, and socially equitable (19). The strong interaction coefficient observed in this study suggests that sustainable digital transformation is most effective when implemented as a coherent and integrated institutional strategy, rather than as isolated initiatives.

The finding that digital governance scored lower than other dimensions reflects one of the most frequently cited barriers in global and regional studies. Governance challenges—such as fragmented decision-making, lack of coordination, insufficient data management systems, and limited digital leadership—are widely reported as major obstacles in digital transformation processes (2, 6). Research within Iranian universities specifically highlights weak governance structures, bureaucratic delays, and inconsistencies in policy implementation as major inhibitors of transformation (12). The qualitative interviews in the present study reinforced this pattern, as participants

emphasized the need for integrated governance, strategic roadmaps, and leadership development. These findings align with studies showing that leadership capacity, governance alignment, and institutional vision are central to successful digital transformation (10, 22).

The moderate mean scores for sustainable infrastructure and environmental sustainability in the quantitative phase also mirror global observations. Many institutions worldwide still struggle to modernize digital infrastructures, reduce energy consumption, and meet sustainability standards due to financial constraints or legacy systems (25). The results also correspond with environmental education models emphasizing the need for green infrastructure and high-level sustainability competencies within higher education (17). Participants highlighted the importance of green data centers, energy-efficient technologies, and environmentally aligned investment strategies, confirming that sustainability cannot be achieved without technological modernization.

The findings also confirm the central role of culture and human competencies. Digital competencies were moderately strong, reflecting partial readiness among academic staff. This aligns with Sahni et al.'s work documenting widespread variability in faculty digital skills and resistance to digital pedagogy in higher education institutions (19). Similarly, Davis and colleagues emphasize that resistance to digital change often emerges from cultural norms, security concerns, and a lack of confidence among faculty members (7). In the present study, cultural readiness and digital competencies were consistently mentioned by experts as conditions for successful transformation, supporting the argument that digital transformation is as much a cultural process as it is a technological one (14).

The identification of localization as a major dimension is particularly important for contexts with strong cultural, regulatory, and structural characteristics, such as Iran. Localization acknowledges that digital transformation frameworks cannot be uniformly applied across nations or institutions. Instead, they must be adapted to local norms, regulatory systems, socioeconomic conditions, and cultural expectations. This is consistent with scholarship showing that national and regional contexts strongly influence the adaptability of digital transformation strategies (21). Local regulatory constraints, funding priorities, and cultural expectations shape institutional behavior and often determine the feasibility of digital adoption (12). The emphasis on localization also parallels UNESCO reports that underscore the increasing necessity of culturally relevant digital models that respect national diversity while maintaining global standards (4).

The findings from ANOVA tests showing significant differences in digital infrastructure, governance, and environmental sustainability across universities highlight systemic inequality within higher education. This aligns with global evidence showing that digital transformation is unevenly distributed across institutions due to differences in funding, leadership, policy environments, and institutional culture (18). The absence of significant differences in educational quality or productivity suggests that academic outputs remain relatively consistent across universities despite disparities in digital and sustainability conditions. This could imply that faculty expertise and pedagogical culture remain stronger predictors of academic outcomes in Iranian universities than digital infrastructure alone.

Finally, the strong correlations between digital transformation and educational quality, and between sustainability and organizational resilience, reinforce the theoretical coherence of the proposed model. Similar associations were documented in Latin America, where digital governance and sustainability initiatives improved institutional performance and resilience (15). European studies also confirm that integrating sustainability with digital transformation leads to higher institutional efficiency and academic innovation (13). These converging lines of

evidence indicate that sustainable digital transformation provides a holistic pathway for enhancing higher education in diverse global contexts.

This study, despite its strengths, contains several limitations. First, the quantitative phase was limited to universities within a single Iranian province, which may constrain the generalizability of results to other regions with different resources, governance structures, or cultural environments. The qualitative phase relied on expert sampling, which, while appropriate for exploratory modeling, may reflect certain biases linked to participants' professional backgrounds or institutional affiliations. The use of self-reported questionnaires introduces additional limitations related to response bias, selective reporting, and variations in respondents' interpretations of digital transformation and sustainability constructs. Finally, although structural equation modeling provides strong evidence of relationships among variables, it does not establish direct causality or capture all potential mediating mechanisms.

Future studies could expand the geographic scope of the sample to include universities from multiple provinces or countries, enabling comparative analyses across different cultural, economic, and regulatory environments. Longitudinal research would be particularly valuable for tracing digital transformation processes over time and understanding how institutional strategies evolve in response to technological, social, and environmental changes. Future research should also explore mediating and moderating variables—such as digital leadership, stakeholder engagement, and policy alignment—to provide deeper insights into the mechanisms linking digital transformation, sustainability, and academic outcomes. Additionally, mixed-methods studies that integrate digital analytics, institutional documents, and case studies could illuminate how successful universities operationalize sustainable digital transformation.

Universities should adopt integrated strategies that align digital transformation with sustainability goals and institutional culture. Leadership development programs are essential for equipping managers with the competencies needed to guide change effectively. Investments in digital infrastructure must be complemented by capacity-building initiatives that improve digital literacy among faculty, staff, and students. Institutions should prioritize inclusive and equitable access to digital resources to ensure that all stakeholders benefit from transformation efforts. Finally, universities should embed sustainability principles into their digital strategies, curricular reforms, and research agendas to enhance long-term resilience and social impact.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adheried in conducting and writing this article.

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.

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