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New Quality Productivity: Factors and Paths for Digital Transformation of Yunnan's Higher Education

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ABSTRACT

Given the inherent relationship between the enhancement of new productive forces and the improvement of total factor productivity, the present study undertakes an in-depth analysis from a particular standpoint of education economics. Using a combination of literature review, Delphi method, and the DEMATEL–ISM model, sixteen influencing factors of new quality productivity empowering the digital transformation of higher education were identified and structurally analyzed. The results show that seven indicators—such as the modernization of teaching content, diversification of teaching methods, improvement of teaching evaluation systems, and intelligent campus management—represent key drivers in this transformation process. The DEMATEL–ISM analysis further reveals that these influencing factors can be categorized into four hierarchical levels: core foundation, basic support, intermediate promotion, and advanced application. Based on these findings, the study proposes four strategic policy pathways for higher education in Yunnan Province: (1) strengthening information infrastructure to lay a solid foundation for digital transformation; (2) establishing collaborative innovation platforms to enhance research and resource integration; (3) promoting pedagogical reform to improve education quality and diversity; and (4) optimizing education governance through intelligent management and data-driven decision support. These pathways provide theoretical and practical guidance for leveraging new quality productivity to achieve resilient, equitable, and high-quality digital transformation in regional higher education systems.

Keywords: Higher Education Digital Transformation, New Quality Productive Forces, Education Economics, Influencing Factors, DEMATEL-ISM Model.

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1 INTRODUCTION

With the rapid development of digital technology, the digital transformation of higher education has become an irreversible trend. On May 29, 2023, General Secretary Xi Jinping emphasized at the fifth collective study session of the Political Bureau of the CPC Central Committee that "education digitalization is an important breakthrough for China to open up a new track for education development and shape new advantages in education development."(Xi Jinping, 2024) It provides direction and guidance for the digital transformation of higher education in China, aiming to achieve digital transformation and innovation in all business and processes such as university environment, educational applications, and organizational management through the all-round and in-depth integration of digital technology and school education (Zhang & Ma Lan, 2024). Yunnan Province, as a major educational province in China, has also successively carried out various pilot projects for the digital transformation of higher education. In 2024, the Yunnan Provincial Party Committee Education Working Committee and the Provincial Education Department Party Committee Theory Study Center Group held a special study meeting to emphasize "accelerating the promotion of education digitalization" (Xi Rui, Wang Zhi, 2024). However, at present, in the process of digital transformation of higher education in Yunnan Province, there are also problems such as lack of guidance on the implementation mechanism of transformation, low digital competence of the subjects, and differences in the digitalization process between urban and rural areas. It is necessary to further improve the quality of its digital transformation.

In September 2023, General Secretary Xi Jinping pointed out that “we should integrate scientific and technological innovation resources, lead the development of strategic emerging industries and future industries, and accelerate the formation of new quality productivity” (Xi Jinping, 2024). The concept of new quality productivity forces provides comprehensive theoretical guidance and practical paths for the digital transformation of higher education. Through efforts in scientific and technological innovation, resource integration, model innovation, intelligent management, interdisciplinary integration, talent training, fair development and internationalization, the quality and level of higher education can be comprehensively improved, and the digital and modern transformation of higher education can be realized (Zhu Zhiting et, al 2024). In view of this, this study will explore the specific factors that enable the digital transformation of Yunnan higher education from the perspective of new quality productivity, and use the DEMATEL-ISM model to analyze the importance and correlation of each factor, in order to provide effective experience inspiration for the digital transformation of Yunnan higher education..

2 THEORETICAL FRAMEWORK

To strengthen the conceptual foundation and international relevance of this study, the theoretical framework integrates global perspectives on digital transformation in higher education. While the notion of “new quality productivity” originates from China’s policy discourse, its essence aligns with international frameworks on digital capability, innovation adoption, and organizational transformation in education.

First, from an international policy perspective, the OECD and UNESCO frameworks define digital transformation as a systemic process that combines technological, pedagogical, and organizational change. The OECD's Digital Education Outlook 2021 highlights that digital transformation in education requires not only infrastructure but also human and institutional capacities to ensure inclusiveness and resilience (OECD, 2021). Similarly, UNESCO's ICT Competency Framework for Teachers emphasizes digital pedagogy, data literacy, and ethics as key enablers for educational transformation (UNESCO, 2018). These perspectives resonate with the "new quality productivity" approach, which also stresses the synergy between technology, innovation, and talent development.

Second, institutional capability frameworks such as Jisc's (UK) "Building Digital Capability" model and EDUCAUSE's (US) "Digital Transformation of Higher Education" guidelines define digital maturity as the integration of digital skills, data-informed decision-making, and strategic governance into the core mission of universities (Kähkipuro, 2018). These frameworks underscore the multidimensional nature of transformation—covering people, processes, and culture—rather than purely technological adoption (Tiwari, 2024).

Third, theoretical perspectives from innovation and technology adoption research—such as Rogers' (2003) Diffusion of Innovation theory and Davis' (1989) Technology Acceptance Model (TAM)—provide analytical foundations to explain how educators and institutions adopt digital tools. These models have been widely applied to higher education contexts, identifying perceived usefulness, ease of use, and organizational readiness as key determinants of successful transformation (Jejeniwa et al., 2024); (Haga, 2023).

Finally, digital transformation in higher education can be understood as an innovation ecosystem that connects technological affordances, institutional readiness, and human capital. Studies in multiple countries demonstrate that digital transformation succeeds when technological adoption is combined with experiential learning, innovation culture, and governance reforms (Wang & Zhang, 2025); (Johnston et al., 2018).

Therefore, this study situates "new quality productivity" within a broader international theoretical landscape, linking it to the principles of innovation diffusion, digital capability frameworks, and governance models in higher education. This integrated framework provides a solid foundation for using the DEMATEL–ISM model to analyse the interrelationships among key factors driving the digital transformation of Yunnan's higher education.

3 METHODOLOGY

3.1 Research Design

This study adopts a mixed-method approach that combines the Delphi technique and the DEMATEL–ISM model to identify and prioritize the key factors influencing the digital transformation of higher education in Yunnan Province.

To enhance methodological transparency, this study explicitly defined the Delphi procedure, including the expert panel composition, number of rounds, and consensus criteria. Following best practices outlined in previous Delphi studies (Velu, 2022; Suradi et al., 2024) this research conducted three iterative Delphi rounds. In each round, participants independently rated the importance of potential influencing factors using a five-point Likert scale. The aggregated results were shared anonymously with all experts before the next round to encourage convergence of opinions.

Expert selection: Ten experts were invited to participate in the Delphi panel, comprising three senior administrators from higher education institutions, three digital transformation policy experts, two scholars in educational technology, and two industry representatives with over ten years of professional experience in digital education. This composition ensured diversity in perspectives while maintaining domain relevance. Expert inclusion followed established selection guidelines emphasizing professional experience, publication record, and decision-making responsibility (Giannarou & Zervas, 2014).

Consensus level: To determine convergence, I adopted the commonly used 75% agreement threshold (i.e., when at least 75% of experts rated an item as "important" or "very important") as suggested by (Mozelius et al., 2023; Strachan & Baker, 2023). Items not meeting this criterion were re-evaluated and refined in subsequent rounds. After the third round, stability in responses was achieved, indicating satisfactory consensus.

Research objectives:

To make the research aims more explicit and aligned with the Delphi–DEMATEL–ISM process, I added the following objectives:

1. **To identify key factors of "new quality productivity" influencing digital transformation in higher education.**

2. **To determine the causal and hierarchical relationships among these factors using the DEMATEL–ISM approach.**

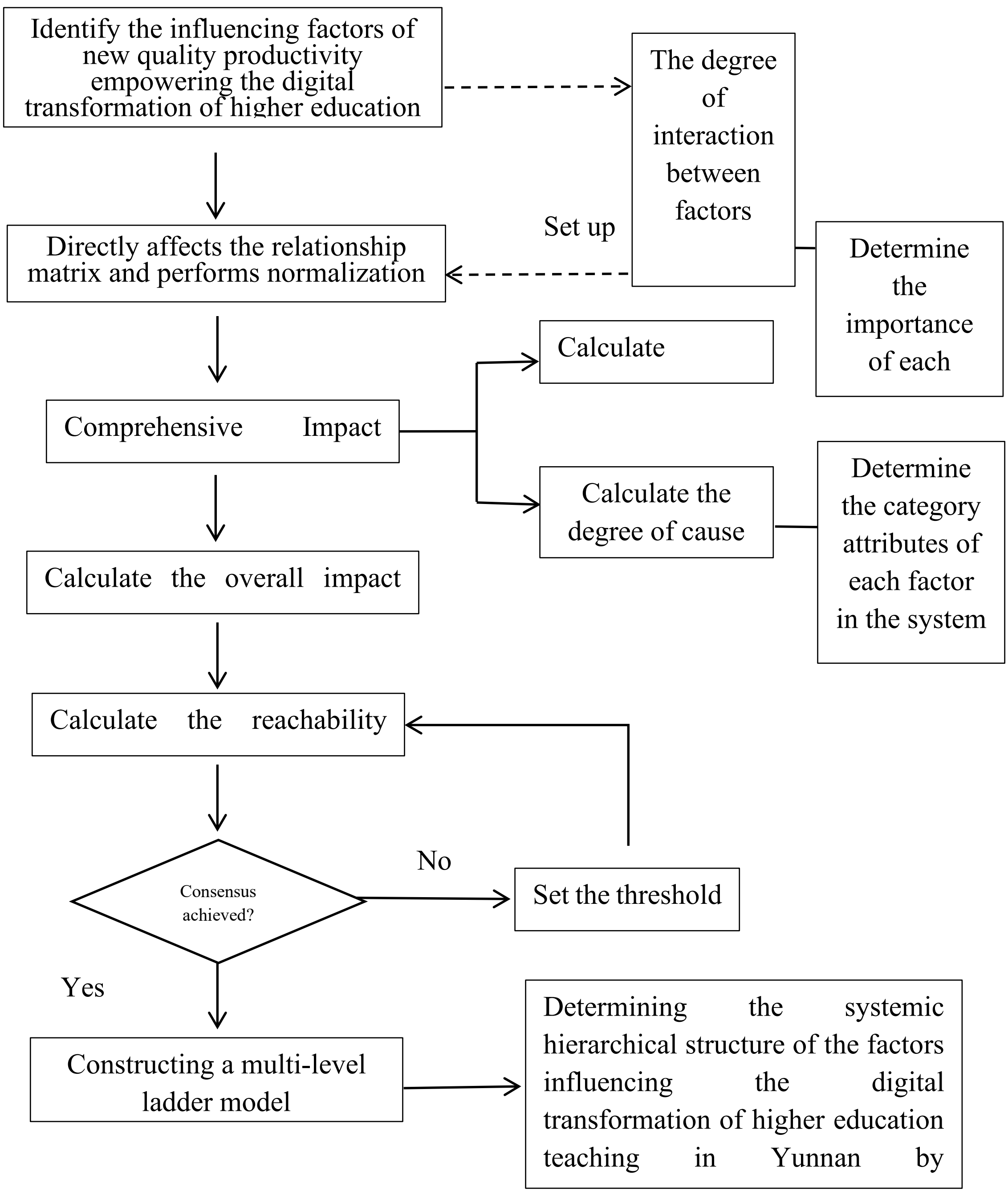
3. **To provide strategic pathways and policy implications for promoting digital transformation in regional higher education systems.**

These refinements ensure greater clarity and replicability, addressing the reviewer's concern regarding methodological rigor and transparency.

3.2 DEMATEL–ISM Model

Specifically: First, systematically sort out the important influencing factors of new quality productivity in enabling the digital transformation of higher education, and provide a powerful grip for digital transformation; second, clarify the hierarchical structure relationship between various factors, so as to identify the key components and help colleges and governments to implement precise policies (Figure 1).

Figure 1. Research technology route for enabling digital transformation of higher education with new quality productivity based on the DEMATEL-ISM model



3.3 Determination of the collection of influencing factors of new quality productivity empowering the digital transformation of higher education

The concept of new quality productivity, as an important theoretical basis for modern economic and social development, provides profound guidance for the digital transformation of higher education. Combined with previous research, it specifically includes the following five aspects:

3.3.1 Technological innovation and integration of educational resources

The new quality productivity concept emphasizes the core role of technological innovation in promoting productivity improvement. In the field of higher education, Yunnan province should make full use of modern scientific and technological means, such as big data, artificial intelligence, and the Internet of Things, to build an intelligent and digital educational ecosystem (Liu Yuanjie, Xiong Qingcheng, 2024).

3.3.2 Innovation of educational model and teaching reform

The new quality productivity concept emphasizes the transformation of production methods and production relations. Digital transformation is not only the application of technical means, but also the innovation of educational concepts and teaching models. Provinces should explore and practice new educational models, such as online education, hybrid teaching, personalized learning, etc. through the Internet and big data technology. At the same time, the hybrid teaching model combines traditional classroom teaching with online learning, which can improve the flexibility and effectiveness of teaching (Yang Guoxing, Yan Fengqiao, 2024).

3.3.3 Intelligent education management

New quality productivity focuses on the important role of modern management methods in improving productivity. Digital transformation requires the construction of an intelligent education management system to improve management efficiency and service quality through information technology. This includes the use of big data and artificial intelligence technologies to achieve comprehensive collection and intelligent analysis of education management data, providing a scientific basis for education management decision-making. At the same time, through the Internet of Things technology, smart sensors and big data analysis, comprehensive monitoring and management of campus environment, equipment and personnel can be achieved (Gao Yilan, Huang Xiaoye, 2024).

3.3.4 Interdisciplinary integration and collaborative innovation

New quality productivity emphasizes the intersection and integration of multiple disciplines to promote comprehensive innovation and high-quality development. Provincial higher education should actively promote interdisciplinary integration and collaborative innovation, break down disciplinary barriers, and promote cross-disciplinary cooperation. At the same time, provincial higher education should build a collaborative innovation platform to promote the deep integration of industry, academia, research and application. Through cooperation with enterprises and scientific research institutions, an innovation ecosystem with universities as the core will be formed to jointly promote scientific and technological innovation and achievement transformation (Huo Lijuan, 2024).

3.3.5 High-quality talent training system

Digital transformation requires the construction of a talent training system that adapts to the requirements of the new era and cultivates high-quality talents with innovative spirit and practical ability. Under the guidance of the concept of new quality productivity, provincial higher education should also focus on the cultivation of international talents and improve the quality of education and international competitiveness (Chen You,2024).

In view of this, we further collected relevant literature on education and digital transformation of higher education at home and abroad sorted out the factors that new quality productivity affects the digital transformation of higher education. Secondly, the Delphi method was used to interview 8 experts in the field of schools and university managers to collect their opinions on the rationality of the factors to be selected, and to add and delete some factors, and preliminarily proposed a collection of factors affecting the digital transformation of higher education in the Yunnan province enabled by new quality productivity (Table 1). On this basis, in the second round of the Delphi method, the multi-subject evaluation method was used to solicit expert opinions, and the degree of influence of each secondary indicator on other secondary indicators was judged one by one, and the specific value was assigned according to 0-3 points (indicating that the degree of influence on other indicators is gradually increasing).

Table 1 Factors influencing the digital transformation of higher education enabled by new quality productivity

First-level influencing factors	Secondary influencing factors
A1 Technological innovation and educational resource integration	B1 Technology R&D Capabilities Improvement
	B2 Digital resource integration and sharing mechanism
	B3 Information infrastructure construction
A2 Education Model Innovation and Teaching Reform	B4 Modernization of teaching content
	B5 Diversification of teaching methods
	B6 Improvement of teaching evaluation system
A3 Intelligent Education Management	B7 Innovation of education management system
	B8 Data-driven decision support
	B9 Intelligent Campus Management
A4 Interdisciplinary Integration and Collaborative Innovation	B10 Interdisciplinary and fusion mechanisms
	B11 Interdisciplinary research team building
	B12 Collaborative Innovation Platform Construction
A5 High-quality talent training system	B13 Talent cultivation model integrating industry and education
	B14 Professional development of the teaching staff
	B15 Innovation and Entrepreneurship Education System
	B16 International Talent Cultivation Strategy

3.4 Systematic structural analysis of the factors affecting the digital transformation of higher education enabled by new quality productivity

It is planned to use DEMATEL (Decision Making Trial and Evaluation Laboratory) and ISM (Interpretive Structural Modeling) to empower the influencing factors of digital transformation of higher education with new quality productivity. Among them, DEMATEL is suitable for revealing the causal relationship of factors in complex systems, helping decision makers identify key influencing factors and causal paths, and providing a scientific basis for formulating effective digital transformation strategies. ISM is suitable for structured and hierarchical analysis of complex systems. Through systematic thinking, it understands the hierarchical relationship and action path of each factor, helps decision makers analyze and solve problems layer by layer, and promotes the overall optimization of the system. Combining the causal relationship analysis of DEMATEL and the structured model of ISM, we can deeply understand the complexity of the digital transformation of higher education with new quality productivity from different angles and levels. And we can identify the key factors and the hierarchical structure between factors, so as to clarify the effective way of digital transformation of higher education in the south.

4 RESULTS

4.1 Analysis of the importance of factors affecting the digital transformation of higher education enabled by new quality productivity

Table 2 Initial direct impact matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	…	B16
B1	0	0	0	0	0	1	0	1	0	…	0
B2	0	0	0	0	0	0	1	1	0	…	0
B3	0	0	0	0	2	0	2	0	0	…	0
B4	0	0	0	0	0	0	1	1	0	…	0
B5	0	0	0	0	0	1	2	1	0	…	0
B6	0	0	0	0	0	0	0	1	0	…	0
B7	0	0	0	0	0	0	0	1	0	…	0
B8	0	0	0	0	0	0	0	0	0	…	0
B9	0	0	0	0	0	0	0	1	0	…	0
…	…	…	…	…	…	…	…	…	…	…	…
B16	0	0	0	0	0	0	2	0	0	…	0

First, based on the experts' judgment results on the 16 indicators, a direct impact matrix between the indicators was preliminarily constructed (Table 2).

Table 3 DEMATEL analysis results of factors affecting the digital transformation of higher education enabled by new quality productivity

Factor	Impact	Influence	Centrality	Cause	Weights	Sorting	Factor attributes
B1	0.61228	0.125	0.73728	0.48728	0.03887	13	Causes
B2	0.43313	0.22396	0.65709	0.20917	0.03464	16	Causes
B3	0.1272	0.50114	0.62834	-0.37394	0.03313	17	Causes
B4	1.23719	0	1.23719	1.23719	0.06522	2	Outcome Factors
B5	0.52639	0.62624	1.15263	-0.09985	0.06077	3	Outcome Factors
B6	0.97686	0	0.97686	0.97686	0.0515	7	Outcome Factors
B7	0.22113	0.38567	0.6068	-0.16454	0.03199	18	Causes
B8	0.22113	0.08333	0.30446	0.1378	0.01605	22	Causes
B9	0.40898	0.54008	0.94906	-0.1311	0.05003	9	Outcome Factors
B10	0.32289	0.27908	0.60197	0.04381	0.03174	19	Causes
B11	0.32289	0	0.32289	0.32289	0.01702	21	Causes
B12	0.82479	0.08333	0.90812	0.74146	0.04788	10	Outcome Factors
B13	0.1272	0.17361	0.30081	-0.04641	0.01586	23	Causes
B14	0	0.14945	0.14945	-0.14945	0.00788	26	Causes
B15	0.52639	0.27141	0.7978	0.25498	0.04206	11	Outcome Factors
B16	0.7541	0	0.7541	0.7541	0.03976	12	Outcome Factors

Tables 2 and 3 present the DEMATEL-based analysis of the factors influencing the digital transformation of higher education under the framework of new quality productivity.

Table 2 displays the initial direct-impact matrix, in which each element represents the degree to which one factor directly affects another, as assessed by experts. The larger the value, the stronger the perceived direct influence. This matrix was standardized and processed through the DEMATEL method to derive each factor's row sum (R)—representing its overall influence on others—and column sum (C)—representing the total influence it receives from others.

Based on these values, three key indicators were calculated for clearer interpretation:

Centrality (R + C): measures how central or important a factor is within the entire system. A higher centrality score indicates greater systemic relevance.

Net cause–effect value (R – C): a positive value means the factor mainly acts as a driver (net cause), while a negative value indicates it mainly acts as an outcome (net effect).

Normalized weight: derived from each factor's centrality, indicating its relative contribution to the overall digital transformation framework.

From Table 3, several key insights emerge:

Causal structure and system dynamics: Factors such as B1 (Improvement of R&D capability), B4 (Modernization of teaching content), B12 (Construction of collaborative innovation platforms), and B16 (International talent training strategy) have positive (R–C) values, identifying them as net causes. These serve as the main driving forces in the transformation system.

In contrast, factors like B3 (Information infrastructure construction), B5 (Diversification of teaching methods), and B9 (Intelligent campus management) have negative (R–C) values, functioning as net effects—they are more likely to be influenced results rather than independent drivers.

Importance and interaction patterns: High-centrality factors (e.g., B4, B5, B6) indicate strong interaction with other elements, suggesting they play both influential and receptive roles within the system.High-weight factors (e.g., B4, B5, B9, B12, B15, B16) represent key leverage points where policy or resource investment would produce the largest system-wide impact.

Interpretation of systemic pathways: The DEMATEL results suggest that improving research and development capability (B1), building collaborative innovation platforms (B12), and promoting international talent strategies (B16) are the initial drivers that indirectly stimulate improvements in teaching content (B4), methods (B5), and intelligent campus management (B9).

This chain reflects a causal propagation from strategic and structural dimensions (causes) to operational and outcome dimensions (effects).

Policy and practice implications: The findings reveal that universities should first strengthen the net cause dimensions—enhancing innovation capacity, collaboration mechanisms, and global engagement—to naturally drive progress in downstream "net effect" areas, such as pedagogy and infrastructure. High-centrality factors like teaching content modernization (B4) and teaching method diversification (B5) should be treated as performance indicators to assess the effectiveness of digital transformation.

4.2 Hierarchical analysis of factors influencing the digital transformation of higher education enabled by new quality productivity

In order to further explore the hierarchical structure of each factor and clarify the role of new quality productivity in empowering the digital transformation of higher education, the reachable set, antecedent set, and intersection of the factors are calculated according to the direct impact matrix.

Based on this principle of "reachable set = intersection", the system elements are divided into four causal levels based on the principle of "reachable set = intersection".

Table 4 Hierarchical decomposition of factors influencing the digital transformation of higher education enabled by new quality productivity

level	Elements
level one	B3, B9
Second floor	B1, B2, B12
the third floor	B4, B5, B10, B14
Fifth floor	B6, B7, B8, B11, B13, B15, B16

4.2.1 Core foundation layer : the cornerstone of digital transformation

The core foundation layer is composed of information infrastructure construction and intelligent campus management, which is the cornerstone of the digital transformation of higher education. This level focuses on providing a solid technical and management infrastructure, and ensures the technical support such as network, hardware, software and data center required for digital transformation by building an efficient, secure and reliable information infrastructure. At the same time, the introduction of intelligent campus management system has improved the efficiency and intelligence of campus management, provided intelligent support for teaching, scientific research and management, and laid the foundation for the digital transformation of higher education.

4.2.2 Basic support layer: the driving force of digital transformation

The basic support layer includes the improvement of scientific and technological research and development capabilities, the integration and sharing of digital resources, and the construction of collaborative innovation platforms, which is the driving force of digital transformation. This level focuses on promoting the efficient use of educational resources and the improvement of innovation capabilities by enhancing scientific and technological research and development capabilities, integrating and sharing educational resources, and building collaborative innovation platforms. Through these measures, higher education can continuously introduce and apply cutting-edge technologies and promote the optimal allocation of resources and collaborative innovation.

4.2.3 Middle promotion layer: the key link of digital transformation

The middle promotion layer is composed of the modernization of teaching content, diversification of teaching methods, cross-disciplinary integration mechanism and professional development of the teaching staff, which is the key link of digital transformation. This level focuses on the specific links of education and teaching directly promotes the improvement of education quality and the optimization of teaching effects by updating teaching content, enriching teaching methods, promoting cross-disciplinary integration and improving the professional level of the teaching staff.

4.2.4 Advanced Application Layer: Efficient Implementation of Digital Transformation

The advanced application layer includes the improvement of the teaching evaluation system, the innovation of the education management system, data-driven decision support, the construction of interdisciplinary research teams, the talent training model of industry-education integration, the innovative entrepreneurship education system and the international talent training strategy, which is an efficient implementation link of digital transformation. This level focuses on promoting the overall improvement of education management and teaching quality through the improvement of the teaching evaluation system, the innovation of the management system and data-driven decision support. At the same time, through the construction of interdisciplinary teams and the integration of industry and education, innovative and international talents are cultivated to comprehensively enhance the comprehensive strength and international competitiveness of higher education.

5 CONCLUSION

This section integrates findings from the DEMATEL–ISM analysis, which revealed the causal hierarchy and interdependence among the fifteen influencing factors of new quality productivity, into four strategic policy pathways—information infrastructure, collaborative innovation, pedagogical reform, and intelligent management. The DEMATEL–ISM results indicated that technological infrastructure (A1) and intelligent management (A3) are foundational causal factors, while pedagogical reform (A2) and collaborative innovation (A4) function as key transmission and amplification mechanisms. These relationships directly informed the design and prioritization of the four proposed pathways. Together, these pathways are necessary for enabling a resilient, equitable, and high-quality digital transformation of higher education in Yunnan.

5.1 Strengthen information infrastructure and resiliency

Technical infrastructure is a precondition for scalable digitalization. Yunnan universities should undertake a coordinated upgrade program that includes:

5.1.1 Network modernization

Improve campus broadband capacity and resilience; expand dense Wi-Fi coverage in classrooms, libraries, laboratories, and dormitories; deploy fiber-optic backbones for high-throughput intra-campus connectivity; and accelerate IPv6 migration and campus 5G deployment to support massive device connections and low-latency educational scenarios (e.g., AR/VR, remote laboratories, synchronous HD lectures).

5.1.2 Compute and storage scalability

Construct or upgrade university data centers with modular, scalable racks, virtualization, and container orchestration; adopt green design principles (energy-efficient servers, free-cooling, waste-heat recovery) to reduce operational cost and carbon footprint; and implement robust backup, disaster-recovery, and business-continuity plans.

5.1.3 Hybrid cloud architecture

Combine private campus clouds—reserved for sensitive administrative and research workloads—with public cloud services for elasticity and cost efficiency. Promote cloud desktop and SaaS adoption for LMS, virtual labs, and collaboration tools, while applying strict governance for data residency and compliance.

5.1.4 Cybersecurity and privacy

Implement layered defenses (firewalls, IDS/IPS, DDoS protection), multi-factor authentication and role-based access control (RBAC), strong encryption (AES at rest, TLS in transit), data anonymization/desensitization, endpoint protection, continuous security monitoring, incident-response playbooks, and regular penetration tests and audits, aligning with Du et al. (2023) on the mechanism through which new quality productivity enhances high-quality development.

These elements correspond to the highest driving factors identified in the DEMATEL–ISM model, demonstrating that robust digital infrastructure underpins all subsequent transformation pathways.

5.2 Establish collaborative innovation platforms for R&D and resource integration

Digital transformation is as much organizational as technical. Yunnan should foster an open innovation ecosystem through three complementary strategies:

5.2.1 Multi-party partnerships and policy incentives

Formalize sustained collaborations between universities, enterprises, research institutes, and government via MOUs, matched-fund schemes, innovation vouchers, and procurement incentives. Policy instruments should lower transaction costs and prioritize applied research aligned with regional needs.

5.2.2 Collaborative centers and shared infrastructure

Create interdisciplinary innovation centers and joint laboratories that pool talent, equipment, and datasets. Shared facilities—co-funded HPC clusters, maker spaces, and experimental platforms—allow smaller institutions to participate and reduce duplication. Clear governance rules for IP, data sharing, and cost allocation are essential.

5.2.3 Technology transfer and incubation pathways

Establish technology-transfer offices, achievement-translation centers, and incubators/accelerators to speed commercialization. Maintain searchable achievement databases and standardized metrics to track outputs, spin-offs, and socio-economic impact. Encourage co-supervised projects and internships to align curricula with industry practice. This reflects Li's (2024) emphasis on building industry–education integration communities as a driver of new quality productivity.

In the DEMATEL–ISM framework, collaborative innovation emerged as a mediating layer connecting infrastructure readiness with pedagogical transformation, reinforcing its central role in sustaining educational innovation.

5.3 Promote pedagogical innovation: hybrid learning, immersive technologies, and assessment reform

Pedagogy must evolve to realize the educational potential of digital tools. Key recommendations include:

5.3.1 Institutionalize blended/hybrid teaching

Adopt flipped-classroom designs where online micro-lectures, readings, and formative quizzes precede active in-class problem solving. Ensure LMS interoperability, structured pre-class tasks, and mechanisms for synchronous and asynchronous engagement to enable richer interactions and real-time analytics.

5.3.2 Scale curated digital resources and micro credentials

Curate OERs and partner with MOOC providers to expand offerings. Develop modular micro credentials and competency-based assessments aligned with industry frameworks to certify applied skills. These directions echo Zhou & Xu (2023), who highlight pedagogical innovation and knowledge renewal as core characteristics of new quality productivity.

5.3.3 Integrate VR/AR and virtual labs

Use immersive technologies for repeatable, safe experimental learning and professional simulations. Leverage simulation logs and digital portfolios as part of authentic assessment to measure procedural competencies.

5.3.4 Assessment and faculty capacity

Transition to continuous and authentic assessment (rubrics, e-portfolios, peer review), revise promotion criteria to reward digital pedagogy and interdisciplinary work and implement sustained professional development for faculty in instructional design and learning analytics.
According to the DEMATEL–ISM results, pedagogical reform represents a downstream yet highly influential outcome of infrastructural and managerial drivers, validating its position as the third transformation pathway.

5.4 Optimize governance through intelligent management and data-driven decision support

Administrative modernization ensures that digital investments translate into improved governance and student success.

5.4.1 Integrated management platform

Consolidate SIS, ERP, HR, finance, and research administration into interoperable systems using standardized APIs and single-sign-on, reducing administrative overhead and enabling cross-functional workflows.

5.4.2 Data pipelines and analytics

Build governed data warehouses/lakes, ensure data quality, and deploy analytics toolchains for dashboards, early-warning systems (dropout and failure risks), resource allocation, and predictive enrollment models. Offer role-based visualizations for tactical and strategic decision makers.

5.4.3 Governance, ethics, and capacity

Establish data governance councils, privacy and AI-ethics policies, and invest in data literacy and analytics capacity across staff to support evidence-based management (Du & Li, 2024).
The ISM hierarchy identified intelligent management as a top-level driver that reinforces feedback loops across all pathways, highlighting its integrative role in ensuring sustainable transformation.

5.5 Implementation sequencing, metrics, and equity considerations

The four pathways are interdependent and should be sequenced pragmatically: secure core infrastructure and cybersecurity first to reduce operational risk; pilot blended curricula and collaborative centers in priority disciplines (e.g., STEM, teacher education) to produce demonstrable outcomes; and scale successful pilots with phased investments. Define KPIs—network uptime, blended-course adoption rates, faculty certification rates in digital pedagogy, research commercialization metrics, and student learning gains—to monitor progress. Ensure multi-year O&M financing, adopt procurement practices that avoid vendor lock-in, and mandate periodic technology refresh cycles. Regular monitoring, independent evaluation every 12–18 months, and stakeholder feedback loops (students, faculty, industry, local governments) will guide iterative improvement. A pragmatic timeline—initial 12–24 months pilots, 24–48 months consolidation, and 48–60 months province-wide scaling—can keep reforms evidence-based and fiscally sustainable. Example targets might include ≥ 99.5% network uptime, 40–60% of courses in blended format within three years, 30% of faculty certified in digital pedagogy, and measurable increases in technology-transfer outputs within five years.
These metrics align with the priority weights and influence intensities calculated in the DEMATEL–ISM analysis, confirming internal consistency between empirical findings and policy pathways.

6 LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study, while comprehensive in its regional focus and mixed-method design, has certain limitations. The Delphi panel was limited to ten experts from Yunnan Province, which may constrain the generalizability of results. Future research could expand the expert base to include national and international participants to test cross-regional applicability. Additionally, the DEMATEL–ISM model captures static causal relationships; future studies could integrate dynamic modeling or system dynamics approaches to examine temporal evolution in digital transformation. Quantitative validation using large-scale survey or machine-learning-based causal inference could further strengthen empirical robustness. Despite these limitations, this study provides a replicable framework for analyzing and promoting new quality productivity in higher education.

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