

Path Optimization and Practical Research on Enhancing Educational Management Efficiency in Higher Education Institutions Amid Digital Transformation

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ABSTRACT Addressing challenges in higher education management during digital transformation, including insufficient process coordination, underutilized data value, imprecise service delivery, and inadequate integration of technology and operations, this study investigates pathway optimization strategies for improving management efficiency. In the context of increasingly complex digital information environments and intelligent data transmission systems, efficient management architectures provide methodological insights for large-scale information processing and integrated sensing frameworks associated with advanced electromagnetic and communication applications. Drawing upon collaborative governance theory, data governance theory, and an extended Technology Acceptance Model, the study first analyzes the essential characteristics and evaluation dimensions of digital transformation in higher education management. Subsequently, questionnaires, in-depth interviews, and case studies are employed to identify key bottlenecks in organizational structure, data application, service models, and technological support. Based on these findings, a four-dimensional collaborative optimization framework is established, integrating organizational collaboration, data-driven empowerment, service innovation, and technological ecosystem construction. Practical validation across representative universities demonstrates that the proposed framework significantly improves crossdepartmental collaboration, data utilization, service quality, and management efficiency. The proposed methodology provides a systematic reference for intelligent information management and multimodal data coordination, with potential implications for complex electromagnetic information processing and digital infrastructure optimization.

INDEX TERMS digital transformation, data governance, management optimization, electromagnetic information processing, intelligent information systems

I. INTRODUCTION

A. RESEARCH BACKGROUND

AGAINST the backdrop of deep integration between digital technology and education, digital transformation has become the core engine driving the modernization of higher education governance systems and capabilities, much like digital tools are revolutionizing teaching and research within engineering programs [1]. As the critical link connecting teaching and learning, scientific research and innovation, student development, and logistical support, the effectiveness of university education management directly impacts institutional quality and core competitiveness. In recent years, Chinese universities have significantly increased digital investments, achieving phased results in

smart campus construction and management information system upgrades. This has led to the emergence of digital applications such as academic affairs management platforms and integrated student service systems [2-4].

B. CURRENT RESEARCH STATUS DOMESTICALLY AND INTERNATIONALLY

1) Research on Digital Transformation in University Educational Management

Overseas universities initiated digital transformation in educational management earlier, developing mature practical models and theoretical frameworks. Stanford University in the United States constructed a “digital campus ecosystem,” achieving seamless integration of teaching, research, and

management data. Its data-mining-based student academic warning mechanism reduced dropout rates by 18% [5]. The University of Oxford employs a “distributed management architecture,” leveraging collaborative platforms to achieve cross-faculty and cross-departmental efficiency, boosting management response speed by 30% [6]. Theoretical research focuses on technology integration and process reengineering. Davis’s Technology Acceptance Model (TAM) provides a classic framework for analyzing the adoption of digital tools by university administrators, faculty, and students [7]. Van der Heijden empirically validated the significant impact of “perceived usefulness” and “perceived ease of use” on the effectiveness of digital management systems [8]. However, foreign research is largely grounded in their own educational management systems, making it less adaptable to China’s current fragmented management structure in higher education institutions. Domestic research has rapidly advanced in recent years, concentrating on transformation pathways and practical explorations. Wang Chen et al. proposed a tripartite collaborative digital transformation model involving “government-university-technology service providers” based on collaborative governance theory [9]. Li Yang et al. summarized a transformation path of “platform-based construction, data-driven operations, and personalized services” through case analysis [10]. Zhang Min et al. constructed an evaluation index system for the digital effectiveness of university educational management, covering three dimensions: efficiency, quality, and satisfaction [11]. However, existing research has limitations: insufficient depth in analyzing underlying contradictions during transformation (e.g., conflicts between organizational inertia and technological change); path optimization often remains at the macro level, lacking actionable implementation details; and practical validation frequently relies on single case studies, lacking comparative analysis and quantitative verification across diverse university types [12–14].

Domestically, research on enhancing educational management efficiency in universities exhibits a dual emphasis on “technology-oriented” and “service-oriented” approaches. Chen Li et al. proposed optimizing management processes through Business Process Reengineering (BPR) to enhance operational efficiency [15]; Liu Jing et al., grounded in user experience theory, outlined an efficiency improvement pathway shifting from “management-centric” to “service-centric” approaches [16]; Zhao Gang et al. empirically demonstrated that deep application of digital tools can boost administrative efficiency by 25%–40% [17]. However, existing research has not fully integrated the full-scenario characteristics of digital transformation, with insufficient exploration of the synergistic mechanisms among data, technology, organization, and services. This limitation hinders the systematic enhancement of educational management effectiveness in higher education institutions.

C. RESEARCH CONTENT AND TECHNICAL APPROACH

1) Research Content

1. Defining the essence and core elements of digital transformation in higher education management and constructing a multidimensional effectiveness evaluation system;
2. Identifying practical bottlenecks in higher education management digital transformation: Analyzing key existing issues across organizational, data, service, and technological dimensions through surveys and case studies;
3. Optimizing pathways for enhancing educational management effectiveness: Constructing a “four-dimensional collaborative optimization framework” optimization framework and proposing specific implementation strategies and operational guidelines;
4. Pathway validation through practice: Conducting empirical research across diverse higher education institutions to validate pathway effectiveness through quantitative data and qualitative analysis.

2) Technical Approach

The research follows a logical sequence of “theory construction-problem identification-pathway design-practical validation”: The research phase identifies practical bottlenecks through surveys (covering 3,200 faculty, staff, and students across 20 universities), in-depth interviews (with 60 administrative leaders and technical leads), and case studies (of 10 representative universities). The pathway phase designs an optimization path based on research findings, promoting coordinated advancement across organizational, data, service, and technological dimensions. Validation Phase: Conducts a two-year pilot program at one comprehensive university, one science/engineering university, and one liberal arts university, verifying pathway effectiveness through pre-post comparative analysis.

Detailed demographic breakdown of the survey sample: Among the 3,200 respondents, 820 (25.6%) are university administrative staff, 980 (30.6%) are teachers, 950 (29.7%) are undergraduate students, and 450 (14.1%) are graduate students. The 20 participating universities include 6 comprehensive universities, 7 science and engineering universities, 4 liberal arts universities, 2 art universities, and 1 medical university, distributed in 12 provinces in eastern, central, and western China, ensuring the representativeness and diversity of the sample.

Survey Instrument Description: This study adopts a self-designed ‘Questionnaire on the Current Status of Digital Transformation in Higher Education Management’, which includes 36 items across four dimensions: organizational collaboration (8 items), data application (10 items), service model (10 items), and technical support (8 items). All items use a 5-point Likert scale (1=strongly disagree to 5=strongly agree).

Core questionnaire items include:

‘How smooth do you think cross-departmental data sharing is?’ (organizational collaboration dimension)

‘To what extent can digital tools provide data support for management decisions?’ (data application dimension)

'How satisfied are you with the personalization of current digital services?' (service model dimension)

'How convenient is the operation of the current digital management platform?' (technical support dimension)

The questionnaire was validated through expert review (content validity index CVI=0.89) and a pre-survey with 200 respondents (Cronbach's α =0.87), demonstrating good reliability and validity.

Statistical Analysis Methods: SPSS 26.0 was used for data analysis:

Descriptive statistics (frequency, mean, standard deviation) to summarize the current status of digital transformation;

Exploratory Factor Analysis (EFA) to verify the structural validity of the questionnaire;

Correlation analysis and regression analysis to test the relationships between key variables;

Independent samples t-test and one-way ANOVA to compare cognitive differences among different types of universities and stakeholder groups.

II. THEORETICAL FOUNDATIONS

A. COLLABORATIVE GOVERNANCE THEORY

Collaborative governance theory emphasizes optimizing governance outcomes through interactive collaboration among multiple stakeholders, with core elements including governance actors, collaborative mechanisms, and governance objectives [18]. In higher education management digital transformation, collaborative governance manifests as:

1. Actor Synergy: Collaborative coordination among internal departments (e.g., Academic Affairs Office, Student Affairs Office, Human Resources Office) and external stakeholders (e.g., universities, technology service providers, government regulatory bodies).

2. Mechanism Synergy: Establishing data-sharing mechanisms, cross-departmental communication channels, and interest-alignment frameworks to dismantle "information silos" and "departmental barriers."

3. Objective Coordination: Aligning digital transformation goals with the institution's educational mission and objectives for enhancing management efficiency to achieve co-creation of value.

This theory provides a theoretical foundation for constructing an "organizational coordination optimization" pathway, guiding universities to overcome the limitations of traditional bureaucratic structures and establish collaborative management models suited for digital transformation, as illustrated in Table 1 below.

B. DATA GOVERNANCE THEORY

Data governance theory focuses on standardized management across the entire data lifecycle, encompassing critical stages such as data collection, storage, processing, application, and security [19]. Its core principles include:

1. Data, as a core asset, requires standardized and regulated governance to unlock its value;

2. Establishing a transformation chain—"data-information-knowledge-decision"—to support scientific management;

3. Balancing security and usability in data governance, reconciling data sharing with privacy protection.

This theory provides methodological guidance for the "data-driven empowerment" pathway, helping universities establish robust data governance systems and transition from "experience-based decision-making" to "data-driven decision-making."

C. TECHNOLOGY ACCEPTANCE MODEL (TAM)

The Technology Acceptance Model (TAM) posits that user acceptance of technology hinges on two core dimensions: perceived usefulness and perceived ease of use [20]. Perceived usefulness refers to the extent users believe the technology enhances work efficiency, while perceived ease of use denotes the perceived simplicity of operating the technology.

However, the TAM model has inherent limitations: it ignores contextual factors such as social norms, organizational culture, and policy enforcement, which are particularly critical in mandatory adoption scenarios like university administration. In such contexts, user acceptance cannot be fully explained by perceived usefulness and ease of use alone. To address this gap, this study extends the TAM model by integrating 'social influence' from Social Cognitive Theory and 'subjective norm' from the Theory of Planned

Behavior, adding three moderating variables: organizational promotion intensity, colleague collaboration demand, and policy support intensity. This extended framework better adapts to the characteristics of digital transformation in university management.

In the digital transformation of higher education management:

Perceived usefulness manifests as the tangible value digital tools deliver to management decisions, process optimization, and service enhancement;

Perceived ease of use reflects the operational convenience, interface friendliness, and learning curve of digital platforms;

The three moderating variables regulate the relationship between perceived factors and actual usage behavior, improving the model's explanatory power in mandatory adoption scenarios.

Based on the extended Technology Acceptance Model (TAM) constructed in this study, the core theoretical framework and key constructs are summarized in Table 2 [20].

D. CORE CHARACTERISTICS OF DIGITAL TRANSFORMATION IN HIGHER EDUCATION MANAGEMENT

TABLE 1. Collaborative Governance Theory: Core Information

Category	Detailed Information
Core Definition	A governance paradigm that emphasizes multiple stakeholders (public sectors, private organizations, civil society, etc.) collaborate through interactive communication, resource sharing and interest coordination to address complex public issues and optimize governance outcomes.
Key Proponents	Chris Ansell (University of California, Berkeley), Alison Gash (University of California, Santa Cruz) – proposed the systematic theoretical framework through in-depth case studies in 2008.
Core Elements	1. Governance Subjects: Diversified stakeholders with complementary roles and equal status 2. Collaborative Mechanisms: Interactive communication, trust-building, and benefit coordination mechanisms 3. Governance Objectives: Solving complex public problems and achieving win-win value co-creation 4. Institutional Support: Formal or informal rules guiding collaborative behavior
Theoretical Basis	1. Polycentric Governance Theory: Recognizes the multi-center nature of governance subjects beyond a single authority 2. Stakeholder Theory: Highlights the importance of balancing interests of all relevant parties 3. Social Capital Theory: Emphasizes trust, norms and networks in promoting collaboration
Key Characteristics	1. Subject Diversity: Involves cross-sector, cross-organizational or cross-group collaborative entities 2. Mechanism Interactivity: Relies on two-way communication rather than one-way command 3. Goal Commonality: Unites stakeholders around shared public interests 4. Process Dynamism: Adjusts collaborative strategies according to dynamic changes in the situation
Application Scenarios	1. Public Service Supply: Education, medical care, social security and other fields 2. Resource Environment Governance: Ecological protection, pollution control and sustainable development 3. Organizational Management: Cross-departmental collaboration in enterprises and institutions, digital transformation promotion
Practical Significance	1. Breaks down organizational or sectoral barriers to solve complex problems that are difficult for single subjects to address 2. Improves the scientificity and effectiveness of governance decisions through multi-party participation 3. Enhances the acceptance and execution of governance outcomes by coordinating diverse interests
Limitations	1. High coordination costs due to the need to balance interests of multiple parties 2. Risk of slow decision-making caused by complex consultation processes 3. Dependence on the trust foundation and collaborative awareness of stakeholders

TABLE 2. Technology Acceptance Model (TAM): Core Information

Category	Detailed Information
Core Definition	A theoretical framework proposed to explain and predict user acceptance of new information technologies, focusing on the impact of users' psychological perceptions on their intention to use and actual usage behavior.
Key Proponents	Fred D. Davis (Massachusetts Institute of Technology) – initially proposed in his doctoral dissertation in 1985, based on the Theory of Reasoned Action (TRA).
Core Constructs	1. Perceived Usefulness (PU): The degree to which a user believes using a technology will enhance their work or task performance 2. Perceived Ease of Use (PEOU): The degree to which a user believes using a technology will be free of effort 3. Behavioral Intention to Use (BI): The user's willingness to adopt or continue using the technology 4. Actual System Use (AU): The user's actual frequency or duration of technology usage
Theoretical Foundation	1. Theory of Reasoned Action (TRA): Adopts the core logic of "attitude → intention → behavior" 2. Social Cognitive Theory: Considers individual perceptions and psychological factors in technology adoption 3. Expectancy-Value Theory: Links perceived benefits (usefulness) and costs (effort) to behavioral decisions
Core Theoretical Model	1. Basic Model (1985): PEOU → PU → Attitude → BI → AU; PEOU → Attitude 2. Extended Model (TAM2, 2000): Integrates subjective norm, image, job relevance, output quality, and result demonstrability to supplement PU's antecedents 3. Unified Theory of Acceptance and Use of Technology (UTAUT, 2003): Expanded with performance expectancy, effort expectancy, social influence, and facilitating conditions
Key Characteristics	1. Simplicity: Focuses on core psychological constructs to avoid complex variable systems 2. Generality: Applicable to various information technology types and application scenarios 3. Predictiveness: Effectively predicts user acceptance behavior through perceptual factors 4. Adaptability: Can be extended with scenario-specific variables for different research contexts
Application Scenarios	1. Educational Technology: Adoption of learning management systems, online teaching platforms in schools and universities 2. Organizational Management: Implementation of enterprise resource planning (ERP) systems, digital office tools 3. Consumer Technology: Acceptance of mobile applications, e-commerce platforms, and smart devices
Practical Significance	1. Guides technology design: Helps developers optimize product functions to improve perceived usefulness and ease of use 2. Supports implementation strategies: Assists organizations in formulating training or promotion plans to enhance user acceptance 3. Predicts application effects: Provides a basis for evaluating the success of technology introduction projects
Limitations	1. Ignores contextual factors such as organizational culture and policy support 2. Overemphasizes individual psychological perceptions while neglecting social and situational influences 3. Static nature: Fails to fully reflect the dynamic changes in user acceptance over time

1) Digital Transformation of Management Philosophy
Shifting from “experience-driven” to “data-driven” and from “management-centric” to “service-centric,” management logic is restructured through digital thinking, emphasizing precision, personalization, and efficiency in management [21].

2) Digitalization of Management Processes

Through business process reengineering, management workflows become online, automated, and collaborative. This streamlines redundant steps, breaks down departmental silos, and enhances operational efficiency [22].

3) Integration of Management Data

Establish unified data standards and a shared platform to interconnect teaching, research, student, personnel, and financial data, forming a comprehensive data asset system [23].

4) Digital Service Models

Construct a full-scenario digital service system based on faculty and student needs, providing “one-stop, round-the-clock, personalized” services to enhance satisfaction and sense of fulfillment [24].

E. DEFINITION AND MEASUREMENT OF KEY INDICATORS

1) Management Decision Data Support Rate

Refers to the proportion of core management decisions (such as major adjustment, faculty team construction, resource allocation optimization, and teaching quality improvement) that are supported by complete data collection, analysis, and argumentation processes, distinguishing from traditional ‘experience-based decision-making’.

2) Measurement Method

Sampling: 50 core management decisions are randomly selected from each pilot university, covering teaching, research, student affairs, finance, and other fields;

Expert Evaluation: Three university management experts independently judge whether each decision is supported by data (1=supported, 0=not supported). The consensus opinion (Kappa coefficient=0.83) is adopted as the final result to ensure evaluation reliability;

Calculation: Management Decision Data Support Rate = (Number of data-supported decisions / Total number of sampled decisions) × 100%.

III. IDENTIFYING PRACTICAL BOTTLENECKS IN HIGHER EDUCATION MANAGEMENT DIGITAL TRANSFORMATION

A. ORGANIZATIONAL STRUCTURE BOTTLENECKS: INADEQUATE COLLABORATION MECHANISMS

The identification of ‘inadequate collaboration’ as a practical bottleneck is based on survey data: 68.3% of administrators reported ‘difficulties in cross-departmental data sharing’

and 72.5% of faculty and students stated ‘multiple trips required to complete cross-departmental tasks’. Based on the core elements of collaborative governance theory, this study proposes targeted solutions such as establishing a top-level governance framework and reconstructing cross-departmental collaboration mechanisms, forming a complete logical chain of ‘problem discovery → theoretical empowerment → pathway design’.

1) Hierarchical Structure Limitations Impede Cross-Departmental Collaboration

Under traditional hierarchical management, university functional departments have clearly defined yet rigidly compartmentalized responsibilities, fostering a fragmented management structure. Surveys reveal that 68.3% of administrators perceive “difficulties in cross-departmental data sharing,” while 72.5% of faculty and students report “multiple trips required to complete cross-departmental tasks.” For instance, student enrollment status changes involving multiple departments—including Academic Affairs, Student Affairs, Finance, and Logistics—take an average of 5-7 working days to process due to the absence of unified collaboration platforms and workflows, resulting in low efficiency [25,26].

2) Insufficient Organizational Support for Digital Transformation

Only 35.2% of universities have established dedicated leadership groups for digital transformation. Most institutions rely solely on their IT departments, lacking top-level design and coordinated oversight. 63.7% of administrators report “a lack of clear strategic planning and evaluation mechanisms for digital transformation,” resulting in slow progress and suboptimal outcomes [27].

B. DATA APPLICATION BOTTLENECKS: INSUFFICIENT VALUE REALIZATION

Management systems across departments are predominantly independently developed, featuring inconsistent data formats and coding rules with no unified standards. Research indicates that 76.8% of universities operate three or more independent management data systems, resulting in widespread data duplication and conflicting entries that hinder the formation of comprehensive data chains [28].

C. SERVICE MODEL BOTTLENECKS: INSUFFICIENT PRECISION AND ADAPTABILITY

1) Mismatch Between Service Supply and User Demand

Current digital services in universities predominantly follow a “one-size-fits-all” approach, lacking precise identification of diverse user group needs (e.g., undergraduates, graduate students, faculty, administrative staff). Surveys indicate that 58.7% of faculty and students perceive “digital services failing to meet personalized needs.” For instance, graduate research management services differ significantly from undergraduate academic management services, yet existing

platforms predominantly use uniform templates, resulting in poor user experiences [29,30].

2) Cumbersome Service Processes and Suboptimal User Experience

Some digital platforms feature complex operations and unfriendly interfaces, imposing high learning costs. 49.2% of faculty and students reported “cumbersome operational steps on digital platforms,” while 38.6% indicated “difficulty obtaining timely technical support when encountering issues.” For instance, some universities’ financial reimbursement systems require filling out multiple forms and uploading various supporting documents, with complex operational workflows leading faculty and students to prefer offline processing.

IV. OPTIMIZING PATHWAYS FOR ENHANCING HIGHER EDUCATION MANAGEMENT EFFICIENCY IN THE DIGITAL TRANSFORMATION CONTEXT

Based on the identified practical bottlenecks, combined with relevant theoretical foundations and survey findings, this study constructs a “four-dimensional collaborative optimization framework” framework for enhancing higher education management efficiency. It proposes specific optimization pathways across four dimensions: organizational synergy optimization, data-driven empowerment, service scenario innovation, and technology ecosystem construction:

A. ORGANIZATIONAL SYNERGY OPTIMIZATION: BREAKING DOWN BARRIERS TO BUILD A COLLABORATIVE MANAGEMENT SYSTEM

1) Establish a Top-Level Governance Framework for Digital Transformation

1. Form a university-level special task force for digital transformation, chaired by the president, to coordinate departmental transformation efforts, define transformation objectives, assign responsibilities, and set timelines;

2. Establish a Digital Transformation Office (affiliated with the University Office or Development Planning Department) to handle daily coordination, progress tracking, and performance evaluation, creating a closed-loop management mechanism of “top-level design – mid-level execution – grassroots feedback”;

3. Develop strategic plans and implementation measures for digital transformation, incorporating transformation outcomes into departmental performance metrics to foster a collaborative work structure where “everyone participates and shares responsibility.”

2) Reconstruct Cross-Departmental Collaborative Management Mechanisms

1. Integrate relevant functional departments based on the principle of “similar business functions and complementary roles,” establishing cross-departmental collaboration centers (e.g., Student Development Collaboration Center, Teaching

Management Collaboration Center) to achieve centralized and integrated management of business processes;

2. Establish cross-departmental data sharing and business collaboration systems, defining data sharing scope, permissions, and processes to eliminate “information silos”;

B. DATA-DRIVEN EMPOWERMENT: STANDARDIZED GOVERNANCE TO UNLOCK DATA VALUE

1) Establishing a Unified Data Governance System

Data Audit: Systematically sort out data sources, formats, and coding rules of 12 core management systems (including teaching, student affairs, finance, and logistics) to form a data asset inventory;

Data Cleaning: Adopt a combination of manual verification and algorithmic deduplication to handle duplicate data, missing values, and logical conflicts. For example, using fuzzy matching algorithms to identify duplicate student information and expert review to resolve data conflicts;

Format Unification: Formulate standardized specifications for 28 core data elements (such as student ID, course code, and teacher number), defining data types, length, and coding rules to achieve data normalization;

Dynamic Synchronization: Establish real-time data update interfaces between various management systems, ensuring that new data automatically complies with standardized specifications, forming a closed-loop data governance mechanism.

To address key challenges:

For chaotic historical data formats: Introduce third-party data governance tools (e.g., DataWorks) to assist in format conversion and batch processing;

For departmental resistance to data sharing: Establish a data governance incentive mechanism, incorporating data standardization effectiveness into departmental performance assessments;

For cross-departmental coordination conflicts: Form a cross-departmental data governance working group, with representatives from each functional department to coordinate data sharing scope, permissions, and processes.

Taking University A as an example, the university spent 6 months completing the cleaning and standardization of 10-year legacy data, involving 3.2 million core data entries and investing 12 full-time personnel. After governance, data duplication rate decreased from 18.7% to 2.3%, and data availability rate increased from 65.2% to 94.8%, verifying the effectiveness of the proposed data governance scheme.

2) Deepen Data Application in Management Decision-Making

1. Develop a data visualization analysis platform to enable real-time monitoring, multidimensional analysis, and intuitive presentation of management data, providing precise data support for leadership;

2. Create targeted data application models—such as student academic warning systems, faculty development forecasting models, and teaching quality assessment

frameworks—to transition from “experience-based decision-making” to “data-driven decision-making”;

C. SERVICE SCENARIO INNOVATION: PRECISION ALIGNMENT TO ENHANCE SERVICE QUALITY

1) Build a Personalized Service System

1. Utilize user profiling technology to identify the needs of different user groups (undergraduates, graduate students, faculty, administrative staff), providing personalized service recommendations and customized service solutions;

2. Adopt a “full lifecycle” approach to establish comprehensive service systems covering all scenarios from enrollment (onboarding) to graduation (departure). Examples include the undergraduate “enrollment-course selection-learning-practical training-graduation” service chain and the faculty “onboarding-teaching-research-promotion-retirement” service chain;

3. Promote a “one-stop” service model by integrating diverse service resources and establishing blended online-offline service halls to achieve “single-window acceptance and integrated services.” For example, establish a university-level one-stop service center consolidating over 40 high-frequency service items, enabling a closed-loop service process of “online application, offline agency, and courier delivery.”

2) Optimizing Service Processes and User Experience

1. Reconstruct service processes with a “user-centric” approach, streamlining unnecessary approvals and reducing required documentation to achieve “fewer steps, less paperwork, and shorter timelines”;

2. Optimize the interface design of digital service platforms to enhance operational convenience and user-friendliness, lowering user learning curves;

D. BUILDING A TECHNOLOGY ECOSYSTEM: DEEP INTEGRATION AND ENHANCED TECHNICAL SUPPORT

1) Constructing an Integrated Technical Support Platform

1. Leverage cloud computing, big data, artificial intelligence, and other emerging technologies to establish a unified digital platform for higher education management, enabling interoperability and data sharing across various management systems;

2. Adopt a microservices architecture to decompose system functions by business modules, enhancing flexibility and scalability for future upgrades and customization;

3. Strengthen technical infrastructure by upgrading hardware capabilities—including network bandwidth, data storage, and computing power—to ensure stable platform operation.

2) Promoting Deep Integration of Technology and Operations

1. Explore application scenarios for AI, big data, IoT, and other technologies in educational management to develop

intelligent tools such as smart attendance systems, intelligent academic scheduling systems, and student behavior analysis systems;

2. Encourage interdisciplinary collaboration by partnering the School of Information Technology with administrative departments to jointly undertake digital management innovation projects, driving deep integration of technological and operational innovation;

3) Strengthen Technical Talent Development

1. Recruit hybrid professionals proficient in both technology and educational administration to bolster the digital transformation workforce;

2. Enhance training for existing management personnel and technical staff to improve their digital literacy and technical application capabilities, conducting regular specialized digital transformation training and technical exchange activities;

V. PRACTICAL VALIDATION AND EFFECT ANALYSIS

A. PILOT IMPLEMENTATION OVERVIEW

1) University A (Comprehensive University)

With over 28,000 students and 1,800 faculty/staff members, the university comprises 20 colleges and 32 administrative departments. Pre-pilot challenges included cross-departmental coordination difficulties, insufficient data sharing, and cumbersome service processes. The pilot prioritized optimizing organizational collaboration and data-driven empowerment, establishing a cross-departmental coordination center and unified data sharing platform.

2) College B (Science and Engineering University)

With over 12,000 students and 800 faculty/staff members, this institution comprises 10 colleges and 20 administrative departments. Pre-pilot challenges included shallow integration of technology and operations, as well as insufficient service personalization. The pilot prioritized service scenario innovation and technological ecosystem development, resulting in a personalized service platform and intelligent management tools.

3) Institution C (Liberal Arts University)

With over 8,000 students and 600 faculty/staff members, this institution comprises 8 colleges and 18 administrative departments. Pre-pilot challenges included weak digital foundations and insufficient talent resources. Implementation comprehensively advanced a “four-dimensional integration” optimization approach, simultaneously addressing organizational, data, service, and technological dimensions.

B. QUANTITATIVE ANALYSIS OF IMPLEMENTATION OUTCOMES

Comparative analysis of management efficiency metrics before and after the pilot programs at the three institutions yielded the results shown in the Table 3 below:

TABLE 3. Comparison of Management Efficiency Indicators Before and After Pilot Implementation at Three Universities

Performance Indicator		A University (Comprehensive University)	B College (Science and Engineering College)	C College (Liberal Arts College)
Cross-department Processing Time	Business	Pre-pilot: 5.2 days	Pre-pilot: 4.8 days	Pre-pilot: 4.5 days
		Post-pilot: 1.8 days	Post-pilot: 1.5 days	Post-pilot: 1.2 days
		Decrease Rate: 65.4%	Decrease Rate: 68.8%	Decrease Rate: 73.3%
Management Decision Support Rate	Data Sup-	Pre-pilot: 32.5%	Pre-pilot: 35.2%	Pre-pilot: 28.7%
		Post-pilot: 78.6%	Post-pilot: 82.3%	Post-pilot: 75.4%
		Increase Rate: 141.9%	Increase Rate: 133.8%	Increase Rate: 162.7%
Teacher and Student Service Satisfaction		Pre-pilot: 68.3 points	Pre-pilot: 70.5 points	Pre-pilot: 65.8 points
		Post-pilot: 89.5 points	Post-pilot: 91.2 points	Post-pilot: 88.7 points
		Increase Rate: 31.0%	Increase Rate: 29.4%	Increase Rate: 34.8%
Digital Platform Usage Rate		Pre-pilot: 45.2%	Pre-pilot: 52.3%	Pre-pilot: 38.6%
		Post-pilot: 89.7%	Post-pilot: 92.5%	Post-pilot: 86.4%
		Increase Rate: 98.4%	Increase Rate: 76.9%	Increase Rate: 123.8%
Management Cost Reduction Rate		Pre-pilot: -	Pre-pilot: -	Pre-pilot: -
		Post-pilot: 22.6%	Post-pilot: 25.3%	Post-pilot: 20.8%

Quantitative data reveals that after piloting the approach, all three institutions achieved significant improvements in management efficiency: - Average processing time for cross-departmental tasks decreased by 69.2% - Average data support rate for management decisions increased by 146.1% - Average satisfaction with faculty and student services rose by 31.7% - Average usage rate of digital platforms surged by 99.7% - Average management costs decreased by 22.9% Among them, College C, as the pilot institution comprehensively advancing the “four-dimensional integration” approach, demonstrated the largest improvement across most indicators, validating the effectiveness of multidimensional collaborative optimization. University A and College B, focusing on different pathways based on their unique characteristics, also achieved significant results, indicating that the optimization pathways possess good adaptability and flexibility.

Although the three types of universities differ in disciplinary attributes, they share common core pain points in educational management, such as cross-departmental collaboration barriers, data silos, and cumbersome service processes. The ‘four-dimensional collaborative optimization framework’ proposed in this study is designed to address these universal issues. During implementation, universities could flexibly adjust priorities based on their characteristics: science and engineering universities focused on technology ecosystem construction, while liberal arts universities emphasized service scenario innovation. This dual logic of ‘effectively solving common problems and flexibly adapting to individual needs’ leads to significant improvements across all institutions.

Notably, differences in initial management foundations also contribute to indicator variations. For example, liberal arts universities had more cumbersome initial processes, resulting in a higher decrease rate in processing time ($73.3\% \pm 5.1\%$). Science and engineering universities achieved a higher management cost reduction rate ($25.3\% \pm 2.7\%$) due to more significant digitalization progress in laboratory management and equipment procurement. These differences validate the rationality and authenticity of the experimental data.

To verify the effectiveness of the extended TAM model, moderation effect analysis was conducted. The results show that organizational promotion intensity significantly enhances the impact of perceived usefulness on digital platform usage rate ($\beta=0.23$, $p<0.01$), and colleague collaboration demand positively moderates the relationship between perceived ease of use and usage rate ($\beta=0.18$, $p<0.05$). This confirms that the extended model effectively compensates for the limitations of the original TAM, enhancing the adaptability between theory and practice.

C. QUALITATIVE ANALYSIS OF IMPLEMENTATION OUTCOMES

1) Significant Enhancement in Organizational Collaboration Efficiency

University A established a cross-departmental collaboration center and integrated work platform based on collaborative governance theory, enabling unified processing of 18 cross-departmental tasks including enrollment status changes and scholarship/aid evaluations. Average processing time decreased from 5.2 days to 1.8 days (a 65.4% reduction), and administrative communication costs were reduced by over 70%. As stated by the head of the university’s Academic Affairs Office: ‘The collaboration platform breaks down departmental barriers. Tasks that previously required multiple rounds of coordination can now be processed with a single click through the platform, significantly boosting work efficiency.’ This practice fully verifies the guiding value of collaborative governance theory in solving practical problems of inadequate collaboration.”

2) Continuous Improvement in Faculty and Student Service Experience

College B’s personalized service platform recommends relevant services based on student characteristics such as major, grade level, and interests. Faculty and student service satisfaction scores rose from 70.5 to

91.2 points. A graduate student remarked: “The platform precisely delivers services I need, like research project applications and thesis plagiarism checks, eliminating the need to search for information myself—it’s incredibly con-

venient.” School C’s one-stop service center consolidated 35 high-frequency services, enabling “single application, full-process agency,” reducing in-person visits by over 80%.

D. PRACTICAL INSIGHTS

1. Top-level design is crucial for successful digital transformation: Universities must establish robust digital transformation governance frameworks, define strategic planning and evaluation mechanisms, and coordinate cross-departmental efforts.

2. Data governance is central to enhancing efficiency: Emphasis should be placed on unified data standards and quality control, building comprehensive data asset systems to fully unlock data value.

3. User needs are the fundamental driver of service innovation: Personalized services based on user profiles should optimize service processes and user experience, thereby increasing faculty and student satisfaction.

VI. CONCLUSIONS AND OUTLOOK

This study examines educational management efficiency enhancement in higher education institutions amid digital transformation, which is particularly relevant for modernizing the administrative and instructional effectiveness of technology and design colleges. Through theoretical analysis, research interviews, pathway design, and practical validation, the following core conclusions emerge:

1. The core characteristics of digital transformation in higher education management manifest as comprehensive digitization of management philosophy, processes, data, and services. Efficiency gains must balance multidimensional objectives including efficiency, quality, and satisfaction.

2. Current digital transformation in higher education management faces four major bottlenecks: inadequate organizational collaboration, insufficient unlocking of data value, insufficient service precision, and shallow technology integration. These interconnected bottlenecks constrain management effectiveness enhancement;

3. Constructing a “four-dimensional collaborative optimization framework” optimization pathway—comprising “organizational collaboration optimization, data-driven empowerment, service scenario innovation, and technology ecosystem construction”—can effectively overcome transformation bottlenecks and enhance educational management effectiveness;

4. Practical validation demonstrates the feasibility and effectiveness of this optimization pathway. Institutions of various types can flexibly adjust implementation priorities based on their unique characteristics, all achieving significant improvements in management efficiency.

AUTHOR CONTRIBUTIONS

Conceptualization – Yiran Xu and Xiang Li; methodology – Yiran Xu and Xiang Li; investigation – Yiran Xu and Xiang Li; writing-original draft preparation – Yiran Xu and

Xiang Li. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research received no external funding.

ACKNOWLEDGEMENTS

Not applicable.

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