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Challenges and Countermeasures of Digital Transformation in Higher Education

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Abstract: Against the dual backdrop of the rapid development of artificial intelligence technology and the advancement of the Digital China strategy, the digital transformation of higher education has become an inevitable choice to improve educational quality and cultivate talents. However, the current transformation process is faced with multiple realistic challenges, including deviations in value concepts, obstacles in teaching practice, weaknesses in guarantee systems, and prominent ethical and security issues. Based on the perspective of educational ecology and combined with the characteristics of educational reform in the AI era, this paper proposes systematic countermeasures from four dimensions: conceptual guidance, practical empowerment, system guarantee, and ethical regulation. The purpose is to provide theoretical reference and practical paths for promoting the high-quality development of digital transformation in higher education and constructing a new ecosystem of smart education.

1. Introduction

The rapid advancement of generative artificial intelligence technologies, exemplified by ChatGPT and leading domestic large-scale models such as DeepSeek and Doubao, is profoundly reshaping global educational paradigms. As a central arena for knowledge transmission and innovation, higher education bears the fundamental responsibility of cultivating high-quality talent suited to the digital era. Its digital transformation has shifted from an optional strategy to an imperative closely tied to the national goal of building a strong education system. Against the backdrop of accelerating digitalization and intelligent technologies, higher education must proactively respond to these changes by advancing reforms in educational philosophy, instructional models, and governance mechanisms, guided by the principles of digital-intelligence empowerment, integration of the digital and real economies, and future-oriented development. By deepening the integration of information technology with teaching and learning, higher education can promote the coordinated development of education, science and technology, and talent cultivation, fostering a

synergistic innovation ecosystem and providing robust intellectual and human capital support for national strategic development.

The digital transformation of higher education is far more than a simple layering of technologies. It entails a comprehensive restructuring of value orientations, teaching models, curriculum systems, teacher-student roles, and governance mechanisms. More fundamentally, it represents a systemic endeavor to build a collaborative ecosystem integrating government, industry, academia, research, and application. Tu [1] proposed that the current digital transformation of higher education faced many challenges in educational philosophy, educational equity, teaching and learning, management and services, educational subjects, and educational governance. Li et al. [2] analysed the inherent mechanisms and challenges of digital transformation in higher education based on the connotation of new-quality productivity, and further investigated the system reconstruction from the perspectives of resource integration, conceptual transformation, and mechanism innovation. Taking Sun Yat-sen University as an example, Chen et al. [3] built a four-dimensional space which consisted of teaching, learning, technology, and management, and to comprehensively implement the digital transformation of higher education. Wang et al. [4] comprehensively reviewed the digital transformation of higher education in China, the United States, and Germany from macro-level national strategy and micro-level governance practices. In addition, they presented four useful insights for the implementation of digital transformation in Chinese higher education: strengthening top-level design with a national strategic perspective, implementing special fund projects in key areas of digital education, collaboratively building digital governance models for higher education, and promoting international exchanges on digital transformation in higher education. Zeng et al. [5] concluded that, the digital transformation of higher education should focus on the following aspects: strengthening humanistic care, balancing value rationality and instrumental rationality; breaking down data barriers and optimizing the mechanism for sharing technological resources; expanding channels for participation from diverse stakeholders, and stimulating the effectiveness of digital governance.

2. Practical Challenges Facing the Digital Transformation of Higher Education

2.1. Deviation in Value Orientations

First, there are notable cognitive deviations in the understanding of digital transformation. Some higher education institutions have an insufficient grasp of its essential meaning and tend to reduce digital transformation to the upgrading and iteration of technological equipment. While they neglect the core imperatives of renewing educational philosophy and restructuring talent cultivation models. Empirical investigations indicate that certain universities narrowly interpret digital transformation as hardware modernization, substantial resources in intelligent teaching platforms and digital devices without systematic planning. In the absence of coherent pedagogical reform strategies and clear implementation pathways, such technology-driven expansion has resulted in a misalignment between digital systems and teaching practices, resulting in a “two-track” phenomenon in which the empowering potential of digital technologies remains unrealized.

Second, there is a growing risk of value alienation in talent cultivation. Under the impact of artificial intelligence technologies, traditional teaching objectives centered primarily on knowledge transmission are increasingly challenged. In some instructional practices, a “technology-first” orientation has emerged, whereby the extent of technological application is treated as the primary indicator of teaching quality. This tendency marginalizes the cultivation of students’ critical thinking, complicated problem-solving abilities, and innovative capacities, thereby deviating from the fundamental educational mission of fostering virtue and nurturing well-rounded individuals. Moreover, divergences in value identification with digital transformation persist among faculty and

students. While some exhibit resistance to the use of digital technologies, others display tendencies toward excessive dependence. Both orientations hinder the active and rational integration of stakeholders into the transformation process, ultimately constraining the overall effectiveness and sustainability of digital transformation in higher education.

2.2. Bottlenecks in Teaching Practice

Insufficient digital competence among teachers has become a key bottleneck hindering the in-depth advancement of digital transformation in higher education. Existing empirical research indicates that while most university teachers possess basic digital technology application skills, they still exhibit significant deficiencies in higher-level competencies required for deep integration of technology and teaching, such as instructional design, implementation, and evaluation. Faced with emerging technologies like generative artificial intelligence, many teachers lack the ability to effectively integrate them into instructional design or develop personalized learning resources. Some teachers even experience technology anxiety, which weakens their willingness and initiative to explore technology-enabled teaching pathways. From an institutional perspective, universities generally lack a systematic and sustainable mechanism for developing teachers' digital literacy. Existing training content largely focuses on basic technical operations, which is disconnected from the needs of integrating technology into teaching. Furthermore, the lack of long-term incentive mechanisms makes it difficult to effectively guarantee the continuous improvement of teachers' digital teaching capabilities.

At the learning level, the prominent problems mainly manifest as a crisis of "alternative learning" and superficial learning depth. The convenience of generative artificial intelligence has, to some extent, fostered path dependence among some students, leading them to over-rely on AI tools when completing assignments and solving problems, thus avoiding key learning processes such as knowledge construction and cognitive investment. This practice of outsourcing learning activities to technology has resulted in a phenomenon of inefficient learning assisted by technology, which not only restricts the development of higher-order thinking skills but also weakens students' self-learning awareness and innovation capabilities. Ultimately, it leads to a distorted learning state of high scores but low abilities. Furthermore, many current digital teaching resources are standardized and fragmented, lacking targeted and inquiry-oriented design. As a result, they fail to meet students' personalized learning needs and effectively stimulate their learning initiative and inquiry motivation, thereby further exacerbating the problem of insufficient learning depth.

2.3. Fragile Support Systems

The imbalance in resource allocation has exacerbated the new digital divide in the process of educational digitalization. At the regional and institutional levels, there are significant differences in investment in digital transformation between universities in the economically developed eastern region and those in the central and western regions, as well as between high-level universities and ordinary undergraduate institutions. The former, relying on substantial funding and policy support, can rapidly build intelligent teaching platforms, conduct information literacy education, and construct high-quality digital learning resource repositories. On the other hand, the latter generally face constraints such as insufficient funding, outdated infrastructure, and limited data resources, resulting in slow and fragmented progress in digital transformation. This uneven distribution of resources directly leads to differences in students' digital literacy development, thereby affecting educational equity and hindering the realization of high-quality development in higher education.

The lack of collaborative mechanisms is another key factor restricting the systematic advancement of digital transformation. As a complex systemic project, the digital transformation of

higher education requires effective collaboration among multiple stakeholders, including governments, universities, enterprises, and research institutions. However, in practice, collaboration among all parties remains insufficient: at the government level, policy coordination and resource integration mechanisms are still imperfect, affecting the accuracy and effectiveness of policy implementation; within universities, barriers exist between departments, with academic affairs departments, IT departments, and various colleges relatively isolated, making it difficult to form a cohesive force for overall advancement; cooperation between universities and enterprises and research institutions is mostly concentrated on technology procurement or equipment supply, with insufficient in-depth cooperation in core areas such as curriculum co-construction, joint teacher training, and scientific research innovation. Consequently, the complementary effects of the various stakeholders' resources and professional advantages have not been fully realized, hindering the effectiveness and sustainable development of digital transformation practices.

2.4. Heightened Ethical and Security Concerns

The widespread application of digital technologies has profoundly impacted traditional academic integrity systems, blurring the boundaries of academic ethics. In actual teaching and research, some students use digital tools to generate assignments, write papers, or complete research reports without truly participating in the core processes of knowledge construction and cognitive training. Whether such behavior constitutes academic misconduct remains controversial, and traditional outcome-oriented evaluation systems struggle to effectively identify technology-generated content, further increasing the difficulty of academic integrity governance and supervision. Furthermore, in technology-assisted research activities, the phenomena of ghost authors and the increase in low-quality output are gradually emerging, weakening the standardization and rigor of academic research and posing a challenge to the existing academic quality assurance system.

During the digital transformation process, data security and privacy protection risks are particularly prominent. The digital development of higher education has generated a large amount of sensitive information, including student personal information, learning behavior records, and teacher teaching data. This information is susceptible to leakage, misuse, or illegal use during collection, storage, use, and sharing. Empirical research shows that some universities have not yet established a sound data governance framework, lack effective security protection technologies, and lack standardized operating procedures, making it difficult to effectively prevent risks such as illegal data transactions and the spread of false data. Furthermore, deficiencies in algorithm design and content management may trigger systemic risks, such as distorted educational content or biased value guidance. Digitally generated systems that lack rigorous content review may spread incorrect or inappropriate values, negatively impacting the formation of students’ values. These issues urgently require attention and effective regulatory intervention.

3. Strategies for Advancing the Digital Transformation of Higher Education

3.1. Embracing Ecological Thinking and Anchoring the Educational Mission

To address the cognitive biases mentioned earlier, universities should move beyond a narrow technology-first mindset and adopt a systematic, balanced, and ecological perspective. Digital transformation should be viewed as a systemic process centered on updating educational philosophies and reconstructing talent cultivation models, rather than simply accumulating technological tools. Through targeted thematic seminars, structured professional development projects, and systematic training, universities can enhance faculty and students' understanding of the core connotations and value orientations of digital transformation, strengthen their value

identification, and encourage their active participation in transformation practices. Under the guidance of the "Digital China" strategy, the development concepts of innovation, coordination, green development, openness, and sharing should be integrated throughout the entire transformation process, with the fundamental goal of promoting the all-round development of people, providing a clear and value-oriented action path for digital reform.

The digital transformation of higher education should always be oriented towards cultivating a new generation of talent who can master technology rather than be dominated by it. Throughout the transformation process, the development of critical thinking, complex problem-solving abilities, creativity, ethical judgment, and lifelong learning capabilities should be integrated. In line with the needs of industrial development in the digital and intelligent era, priority should be given to improving students' digital literacy and innovative application capabilities, responding to the new talent cultivation paradigm of "digital intelligence empowerment, digital-real integration, and digital-led future." In teaching practice, universities must transcend the limitations of passively adapting to technology and proactively construct a new educational paradigm centered on promoting students' advanced development. By utilizing digital and intelligent technologies to optimize tiered teaching and personalized learning paths, it is possible to effectively prevent educational goals from being distorted by technology, ensuring that digital transformation always serves to improve the quality of talent cultivation.

3.2. Enhancing Faculty Competence and Innovating Teaching Models

Building a systematic framework for teacher development is fundamental to enhancing teachers' digital teaching capabilities. Universities should design tiered and categorized training systems based on the Ministry of Education's “Industry Standards for Teacher Digital Literacy”, tailored to different disciplinary backgrounds and career development stages. The focus of training should shift from basic technical operations to cultivating advanced skills, including instructional design integrating artificial intelligence, implementation of formative assessment, and critical reflection on educational data ethics. Drawing on the practical experience of universities in improving digital teaching capabilities, institutions should promote the development of grassroots teaching organizations and targeted digital literacy enhancement projects. Through diversified mechanisms such as teaching competitions, results promotion and master teacher studios, excellent practices in digital teaching can be effectively amplified and disseminated. Simultaneously, a teaching innovation incentive system integrating collaborative teams, cross-departmental collaboration, and performance evaluation should be established, incorporating the achievements of digital teaching reforms into teacher assessment and recognition mechanisms, thereby empowering teachers to transition from knowledge transmitters to learning facilitators and collaborators.

Innovating digital teaching models is essential for deepening human-machine collaborative education. Taking major initiatives such as digitally intelligent discipline leadership, digital-intelligent curriculum development, and pilot projects for new-format digital textbooks as key levers, universities should construct a “five-in-one” talent cultivation pathway. At the disciplinary level, this involves advancing the development of AI-focused majors, AI-integrated interdisciplinary programs, and micro-credential systems to enhance alignment between academic offerings and evolving industrial demands. At the curriculum level, institutions should develop a “1+1+N” digitally empowered course matrix, supported by knowledge graphs for core disciplinary courses to enable the integration and interoperability of key concepts. At the instructional materials level, planning and launching new-generation digital textbooks can help establish multidimensional knowledge carriers.

Full use should be made of AI’s personalization potential by building integrated, adaptive

“teaching-learning-management” platforms based on large educational models for emerging engineering education. Through AI-driven analysis of learning analytics data, customized learning pathways and adaptive resources can be provided for diverse student needs. Intelligent simulation technologies can be leveraged to support practice-based teaching in high-risk or high-cost scenarios, thereby enhancing experiential learning outcomes. Furthermore, universities should vigorously promote project-based and inquiry-based learning, deliberately designing authentic, complex, and interdisciplinary engineering problems that cannot be directly solved by AI. Such approaches encourage students to integrate knowledge and refine higher-order thinking in the problem-solving process, effectively mitigating the superficialization of learning depth. Finally, disciplinary boundaries should be transcended by incorporating AI ethics, data literacy, and related topics into the core of general education curricula, while embedding humanistic, ethical, and societal perspectives within specialized courses. In doing so, higher education can cultivate “technological humanists” who possess both advanced technical competence and a strong sense of humanistic responsibility.

3.3. Optimizing Resource Allocation and Building a Collaborative Ecosystem

Optimizing the structure of resource allocation is essential for advancing digital equity in education. In response to the “new digital divide” arising from uneven resource distribution, governments should strengthen top-level coordination and increase policy support and financial investment for the digital transformation of higher education institutions in central and western regions as well as local universities. Mechanisms for the sharing of high-quality digital educational resources should be further institutionalized. Leveraging the National Smart Education Public Service Platform, leading universities can be encouraged to disseminate high-quality course resources, exemplary teaching cases, and research outcomes to local institutions, thereby narrowing inter-institutional resource gaps. At the institutional level, universities should formulate differentiated resource investment strategies based on their own missions and development priorities, giving precedence to critical areas such as the digitalization of core teaching resources and the construction of foundational technological platforms, while avoiding unreflective benchmarking and inefficient resource duplication. In addition, regional collaborative development mechanisms can be strengthened through inter-university support programs, faculty exchanges, and joint teaching and research initiatives, further mitigating structural inequalities in resource allocation and safeguarding educational equity.

Building an integrated “government-industry-academia-research-application” collaborative ecosystem is a pivotal pathway for sustainable digital transformation. Governments should enhance top-level design by formulating medium- and long-term development plans for the digital transformation of higher education, clearly delineating the responsibilities of each stakeholder and establishing coordinated governance mechanisms to ensure the effective integration of resources and the implementation of policies. Universities, in turn, should dismantle internal departmental silos and establish cross-functional coordination mechanisms characterized by joint leadership from party and administrative authorities, centralized coordination by academic affairs units, interdepartmental collaboration, and college-level implementation. Dedicated leadership groups for digital–intelligent teaching reform, along with specialized task forces focused on disciplines and curricula, can help consolidate collective momentum for transformation. Moreover, universities should proactively deepen partnerships with enterprises and research institutes by introducing cutting-edge technological platforms and industry projects, jointly advancing curriculum development, faculty training, and collaborative research, and fostering a development model that integrates endogenous capacity building with external support. Finally, by leveraging the National

Smart Education Public Service Platform to promote the sharing of high-quality digital–intelligent teaching resources, local universities can be supported in narrowing transformation gaps, strengthening ecosystem connectivity, and enabling the smooth circulation of material, energy, and information across the collaborative network.

3.4. Improving Institutional Frameworks and Strengthening Risk Governance

Improving academic ethics systems is essential for clarifying the boundaries of AI application. Universities should formulate discipline-sensitive guidelines for the use of artificial intelligence, clearly delineating the functional scope and permissible limits of AI tools in general education and specialized courses, and defining acceptable practices and integrity thresholds for AI-assisted learning and research. Mechanisms for the identification and supervision of AI-generated content should be established by integrating technological approaches, such as digital watermarking and blockchain-based traceability, with academic integrity pledge systems, thereby forming a tripartite safeguard structure encompassing technology, institutional regulation, and academic culture. At the same time, assessment systems should be reformed by shifting from outcome-oriented evaluation toward process-based and developmental assessment. Through multidimensional evidence, including learning portfolios, oral defences, peer assessment, and AI-generated analytic reports, institutions can comprehensively evaluate students' cognitive processes, practical competencies, and developmental trajectories, thus mitigating academic integrity risks associated with AI use.

Strengthening data security governance is equally critical for reinforcing privacy protection. Comprehensive educational data governance frameworks should be established to clearly specify procedures and responsibilities related to data collection, storage, utilization, and sharing, ensuring compliance and security across the data lifecycle. Greater investment should be directed toward the development and deployment of data security technologies, including encryption, access control, and anomaly detection systems, to prevent data leakage and misuse. In parallel, universities should establish clear ethical guidelines and academic norms for AI use within institutional settings and promote extensive ethics education and dialogue. By cultivating a campus culture that encourages the responsible, critical, and creative use of AI, institutions can enhance faculty and students' awareness of data security and strengthen their ethical literacy, thereby providing a robust normative foundation for the sustainable digital transformation of higher education.

4. Conclusions

The digital transformation of higher education is inevitable in the digital era, as well as critical for advancing high-quality educational development and building a strong education system. The present study first analyses the challenges encountered in the transformation process, including deviations in value orientations, bottlenecks in teaching practice, fragile support systems, and heightened ethical and security concerns. These challenges require coordinated efforts among multiple stakeholders to construct a comprehensive and multi-layered response framework.

To address these multifaceted challenges, this study further proposes a comprehensive set of countermeasures aimed at fostering the high-quality advancement of digital transformation in higher education. First, conceptual leadership must be prioritized, adopting an ecological perspective and firmly anchoring the principle of digitally intelligent empowerment in talent cultivation. Second, practice-oriented empowerment should form the core, bolstering pedagogical effectiveness through systematic faculty development and innovative refinement of the integrated "five-in-one" talent cultivation framework. Third, robust systemic safeguards are essential, entailing optimized resource allocation and the cultivation of collaborative ecosystems that promote cross-departmental coordination and deep government-industry-academia-research-application integration.

Fourth, ethical governance must serve as the foundational safeguard, realized through ongoing refinement of institutional norms and enhanced risk management. This transformation will cultivate innovative, application-oriented talent capable of navigating and leading in the digital intelligence era, thereby providing essential human capital for the integrated progression of education, science and technology, and talent development.

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