Research on the Digital-Intelligent Transformation Model of Postgraduate Course Teaching Based on the TOE Framework

Chuanyu Peng[1] Lingyu Zhao[2]

[1,2] *School of Public Administration, Southwest Jiaotong University, Chengdu 610031, China*
[2]*Corresponding author. Email: lingyu.zhao@my.swjtu.edu.cn*

ABSTRACT
Against the backdrop of a global digital transformation and national strategies for educational digitalization, the digital transformation of postgraduate course teaching has become a pressing imperative. Grounded in the Technology-Organization-Environment (TOE) framework, this study thoroughly analyzes the practical challenges impeding this transformation, including the inherent limitations of traditional pedagogical models, misalignments in technology application, and the absence of a comprehensive digital ecosystem. Accordingly, this study proposes a model for the digital transformation of postgraduate course teaching. The model encompasses three core dimensions: (1) a system for pedagogical innovation driven by digital and intelligent technologies; (2) the synergistic reform of teaching structures and stakeholder relationships; and (3) the development of smart learning environments that merge virtual and physical realities. This model is intended to offer valuable insights for the digital transformation of postgraduate education, contributing to the enhancement of course quality and effectiveness.

Keywords: *TOE framework, Digital transformation, Course teaching model, Postgraduate education.*

1. INTRODUCTION

In the contemporary era, the world is undergoing a profound digital transformation, compelling sectors globally to adopt digital technologies to enhance efficiency and competitiveness. Within this international context, China has made educational digitalization a national strategic priority, rolling out a comprehensive set of policies to drive this agenda forward.

This national commitment is underscored by recent high-level policy directives. The report from the 20th National Congress of the Communist Party of China, for example, introduced the strategic initiative to “advance educational digitalization,” with the stated goal of fostering educational innovation and establishing the nation as a global leader in education. This sentiment was echoed by General Secretary Xi Jinping, who emphasized that digitalization offers a critical opportunity to forge new paths and secure competitive advantages in educational development.

Graduate education, as the apex of the higher education system, is central to this reform effort and is considered vital for cultivating talent with advanced scientific and technological innovation capabilities. Recognizing this, in June 2023, the Ministry of Education specifically called for “promoting the enhancement of teaching quality through digitalization,” signaling a clear focus on transforming instructional practices. Because graduate education is tasked with the core mission of developing the nation’s high-level innovative talent, the digital transformation of its pedagogical models is a matter of considerable urgency.

The significance of this study is twofold. First, the digital transformation of graduate-level teaching is essential for developing elite talent. It enables personalized and diversified learning experiences that are crucial for stimulating the innovative thinking and practical skills required to compete globally. Second, this transformation is an indispensable component of the broader national push for high-quality educational development, as digital pedagogies can enhance instructional efficiency and quality, expand access, and accelerate the modernization of the entire educational ecosystem.

Therefore, this study aims to propose a new model for the digital transformation of postgraduate course teaching. We employ the Technology-Organization-Environment (TOE) framework as our analytical lens. The TOE framework facilitates a systematic examination of the challenges inherent in this transformation across the distinct yet interconnected dimensions of technology, organization, and environment. This analysis provides the theoretical foundation and practical insights necessary for the construction of the proposed model.

2. PRACTICAL CHALLENGES IN THE DIGITAL TRANSFORMATION OF POSTGRADUATE COURSE TEACHING

2.1 Limitations of Traditional Models in Achieving Student-Centeredness

First, traditional pedagogy is characterized by a teacher-centric model of unilateral knowledge transmission. Within this framework, the instructor primarily functions as a dispenser of information, creating a unidirectional flow from educator to learner. Such an approach inherently limits students' engagement in the active construction of knowledge and curtails the development of critical thinking capacities [5]. Moreover, the lack of robust learning feedback mechanisms means that instructors are often unable to accurately diagnose student misconceptions, leading to a frequent disconnect between the intended curriculum and students' actual comprehension.

Second, the administrative and pedagogical management of courses within traditional models suffers from inherent rigidities. Strict adherence to predetermined syllabi and instructional procedures minimizes opportunities for student-led inquiry and intellectual exploration [1]. The evaluation systems in these models are also problematic, as they tend to prioritize easily quantifiable metrics, like examination scores, at the expense of assessing more holistic competencies, such as self-directed learning abilities and applied practical skills. This narrow evaluative focus often results in a significant disparity between assessment results and a student's true capabilities.

2.2 Insufficient Integration of Technology with Pedagogy in Traditional Models

First, an overreliance on quantifiable metrics risks marginalizing essential, non-measurable dimensions of education. There is a prevalent tendency to prioritize data-driven assessment, which often reduces complex pedagogical processes, such as the nuances of teacher-student cognitive interaction, to simplistic data points. This quantitative focus means that crucial yet intangible aspects of learning—including students' emotional engagement, their cognitive maturation, and the development of ethical values—are systematically overlooked, potentially leading to a highly mechanistic and impersonal mode of instruction.

Second, the integration of technology into pedagogy frequently remains superficial. In many cases, technological tools are simply layered onto existing teaching formats without catalyzing fundamental pedagogical innovation. For instance, multimedia presentations or learning management systems are often adopted without restructuring the underlying organization of content or instructional methodologies. Digital resources may function as little more than electronic substitutes for traditional blackboards, thereby failing to optimize knowledge transfer or foster deep student engagement. This represents a significant underutilization of technology's transformative potential.

Third, the application of educational technology is often skewed toward administrative management. Institutional efforts and resources are disproportionately channeled into standardizing procedural tasks, such as automated attendance monitoring or the analysis of assignment submissions, while its potential for providing deep academic mentorship or rich resource support remains underexploited. Consequently, there is a danger that technology is perceived not as a facilitator of learning but as a mechanism of administrative control, offering little substantive support for genuine intellectual growth or the cultivation of scholarly innovation.

2.3 Lack of a Comprehensive Digital Ecosystem in Postgraduate Education

First, there is a significant imbalance in the distribution of digital resources across disciplines and a notable lack of cross-disciplinary development. While many universities are investing in virtual simulation laboratories, these resources are often heavily skewed toward technical fields, with engineering resources far surpassing those available to the humanities and social sciences. This disparity severely limits opportunities for postgraduate students in the humanities to develop essential digital literacy and innovation competencies. Furthermore, the majority of these virtual environments are confined to single-discipline contexts, failing to provide the interdisciplinary scenarios necessary for addressing complex, multifaceted problems. As a result, they are ill-suited to cultivate the talent required for emerging interdisciplinary fields, such as the “New Liberal Arts” and “New Engineering”.

Second, a persistent mismatch exists between available technological applications and the specific needs of postgraduate education, alongside a growing digital divide among institutions. The deployment of advanced technologies, including VR laboratories and AI-driven smart classrooms, is paradoxically more prevalent at the undergraduate level, a phenomenon described as an “inverted hierarchy” [2]. This issue appears to originate from a fundamental miscalculation of the distinct requirements of postgraduate study. As an advanced stage of intellectual development, postgraduate education demands sophisticated tools that support research activities—such as intelligent literature analysis systems and virtual collaborative research environments. In contrast, many existing institutional platforms are designed primarily for content delivery, thus offering insufficient support for the core scenarios of research and innovation that define postgraduate work.

Third, the development of a robust digital ecosystem is often impeded by misplaced institutional priorities. A common pitfall is an overemphasis on physical hardware and administrative software. Consequently, digital transformation funds are disproportionately allocated to procuring devices and management systems, while the crucial areas of digital content creation and pedagogical integration are neglected. This hardware- and management-centric strategy results in a poorly balanced ecosystem that is inadequately equipped to support the substantive transformation of postgraduate teaching and learning.

3. APPLICABILITY OF THE TOE FRAMEWORK TO THE DIGITAL TRANSFORMATION OF POSTGRADUATE COURSES

The Technology-Organization-Environment (TOE) framework, a seminal model explaining technology adoption in organizations [9], provides a robust analytical lens for examining the digital and intelligent transformation of postgraduate education [7]. Its tripartite structure—analyzing the interplay of technology, organization, and environment—allows for a systematic deconstruction of the required shifts in pedagogical elements, stakeholder roles, and external support systems [6, 8].

In the technological dimension, the deep integration of intelligent tools into pedagogical processes yields significant efficiency gains. Automated systems can analyze learning analytics to curate personalized learning pathways and deliver customized content. Virtual simulation technologies, such as those used for virtual laboratories in STEM fields, render abstract concepts tangible while simultaneously reducing operational costs. Efficiency is also enhanced through optimized task allocation; for example, AI-powered teaching assistants can manage routine administrative tasks like grading, allowing human instructors to dedicate their expertise to fostering higher-order competencies, including critical thinking and research mentorship. This reallocation of effort directly contributes to an overall improvement in teaching quality.

In the organizational dimension, this transformation demands a dynamic restructuring of institutional roles and coordination. The role of the instructor evolves from that of a mere knowledge transmitter to a “learning designer” who architects flexible educational experiences that encourage student inquiry. Accordingly, students transition from being passive information recipients to active co-constructors of knowledge [4]. The success of this transition hinges on organizational readiness. This includes establishing clear standards for blended learning to ensure a seamless fusion of online and offline modalities, as well as implementing robust professional development mechanisms to enhance the digital competencies of both faculty and students, thereby maximizing the pedagogical return on technology investment.

In the environmental dimension, synergistic support from the external ecosystem is critical.

Top-down support, such as national digital education policies, provides strategic direction and financial resources. The underlying digital infrastructure, including high-speed networks and regional cloud computing platforms, is essential for operational stability and equitable resource access. Moreover, evolving industry demands create a market pull, aligning postgraduate curricula with real-world applications and ensuring graduates possess market-relevant skills. The impact of technology is thus context-dependent: environments with strong policy frameworks and advanced infrastructure act as accelerators for transformation, while their absence serves as a significant constraint. Consequently, bolstering policy support and infrastructural capacity are critical enablers of success.

Ultimately, the TOE framework serves as a powerful analytical tool for navigating the digital transformation of postgraduate education. By examining the interplay across these three dimensions, it illuminates the core logic of this process: profound pedagogical innovation is achieved through the synergistic convergence of technology-driven process enhancements, organization-led relational restructuring, and environment-facilitated support. This perspective offers vital insights for cultivating digital literacy and strategically advancing the evolution of higher education.

4. CONSTRUCTING A DIGITAL TRANSFORMATION MODEL FOR POSTGRADUATE COURSES BASED ON TOE THEORY

4.1 Technology Enablement: Teaching Innovation System Driven by Diverse Digital Technologies

The first strategic imperative is to upgrade the next-generation digital infrastructure. This requires the establishment of a robust technological support system for the smart campus, built upon core components including intelligent teaching terminals, IoT-integrated campus facilities, unified educational data platforms, and ubiquitous 5G connectivity.

A second priority is to deepen the synergy between technology and pedagogy. At the application level, this calls for sustained investment in advanced technologies such as artificial intelligence and big data to ensure their meaningful integration into postgraduate education. This strategy involves two key thrusts. First, the provision of high-quality digital learning resources must be expanded, and their application scenarios broadened. Platforms such as MOOCs, virtual classrooms, and digital resource repositories can be leveraged to offer foundational and specialized courses that cater to the diverse and personalized learning pathways of postgraduate students. Second, universities must proactively develop or procure next-generation intelligent teaching hardware and software, supported by a dynamic mechanism for updates and maintenance. The deployment of these tools enables the precise monitoring of student performance and sophisticated analysis of learning data, thereby providing an empirical foundation for designing tailored instructional strategies.

The third recommendation is to optimize and innovate teaching methodologies. The inherent capabilities of digital technologies—including rapid information dissemination, large-scale data storage, and process automation—provide fertile ground for pedagogical innovation. For instance, integrating computational thinking into disciplinary curricula, such as by incorporating low-code development platforms, can empower postgraduate students to use advanced tools for analyzing complex problems, thus strengthening their inquiry-based learning skills [3]. Furthermore, applying big data analytics to perform multi-dimensional analyses of student learning trajectories allows for the precise identification of learning impediments. This data-driven insight enables educators to make targeted adjustments to their teaching strategies, leading to measurable improvements in educational quality.

4.2 Organizational Restructuring: The Synergistic Transformation of Structures and Roles

First, the reform of the teaching structure is demonstrated through a flexible curriculum system. This framework is composed of three integral parts: foundational theory courses, interdisciplinary methodology courses, and applied research courses. Foundational courses equip students with a robust disciplinary knowledge base. The interdisciplinary courses are designed to develop students' holistic thinking and innovative capacities, enabling them to analyze problems from multiple perspectives. In the applied research courses, students translate theoretical knowledge into practice, thereby enhancing their practical competencies and research proficiency. Such a curriculum structure is intentionally designed to be more adaptive to the varied learning requirements and career trajectories of postgraduate students.

Second, an AI-human co-teaching system is proposed to redefine stakeholder relationships. Within this synergistic model, an AI tutor is responsible for knowledge navigation and methodological support, offering customized learning pathways and research strategies tailored to each student's progress and academic focus. The human mentor, in parallel, concentrates on fostering students' humanistic qualities, creative insight, and scholarly integrity. This integration establishes a novel and collaborative mentorship paradigm.

Third, this organizational restructuring requires a bidirectional and interactive ecosystem. Digital profiling technologies are utilized to capture and analyze student learning data, furnishing educators with rich analytics to inform their pedagogical strategies. Furthermore, generative dialogue systems facilitate substantive discussions among students, faculty, and peers, stimulating knowledge co-construction and innovation. This transforms the pedagogical model from one of unilateral information delivery to a model of open exchange and collaboration. In this framework, students transition from being passive consumers of information to active participants and creators of knowledge. This open environment empowers them to share insights and findings, thereby contributing to the collective advancement of their academic fields.

4.3 Environment Optimization: The Construction of Integrated Smart Learning Environments

First, the proposed smart learning environment integrates intelligent monitoring. By leveraging digital twin systems, real-time data on student learning processes are continuously collected. Predictive analytics are then applied to these data to accurately assess students' learning progress and identify early signs of academic burnout, facilitating timely pedagogical interventions. This allows educators to recognize when students are struggling and implement targeted support to help them recalibrate their learning strategies.

Second, immersive cognitive spaces are constructed using Extended Reality (XR) technology. In disciplines from STEM to the humanities, XR can generate high-fidelity virtual environments for experiments and scenario-based learning. This provides students an immersive experience, or a sense of "being there", as they engage with the material. Such a blended physical-virtual modality not only mitigates the costs and constraints of traditional laboratory work but also enhances students' computational thinking and systems design skills via immediate, data-driven feedback.

Third, the environment is underpinned by data-driven learning networks. Knowledge graphs are employed to map and integrate extensive academic resources, presenting students with structured knowledge systems and guiding them toward promising research trajectories. This supports the identification of novel research questions and improves the originality of their academic choices. Concurrently, regional academic cloud platforms promote the efficient circulation and sharing of scholarly resources. Ultimately, this integrated smart learning environment, merging physical and virtual modalities, is designed to elevate students' cognitive paradigms. It develops skills in embodied cognition, allowing students to internalize knowledge through direct application, while also fostering a holistic, scholarly mindset necessary for driving academic innovation from a macro-level perspective.("Figure 1")

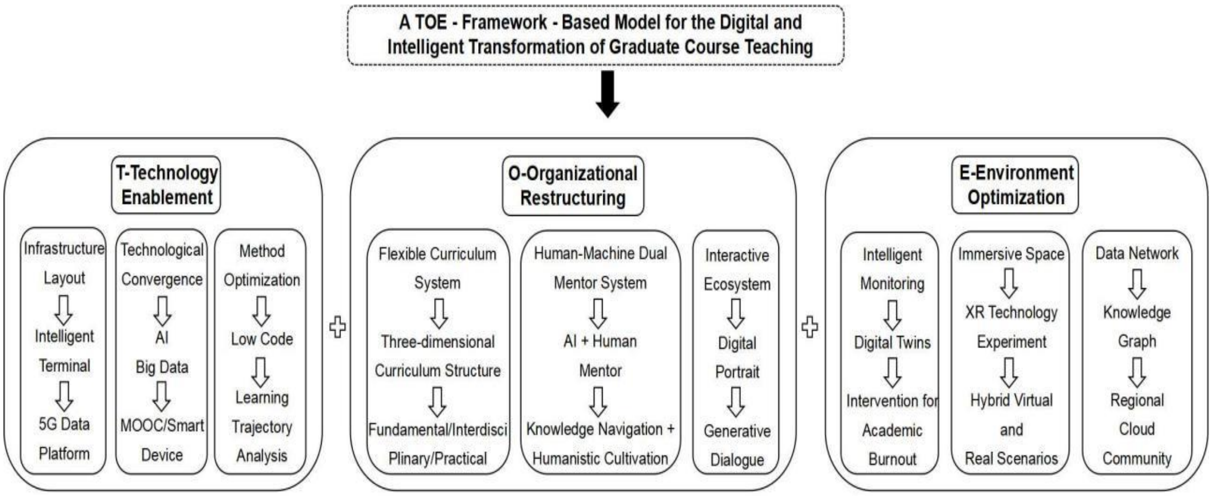

Figure 1 The development path of the toe-framework-based model for the digital and intelligent transformation of graduate course teaching.

5. CONCLUSION

The ongoing digital and intelligent transformation of the education sector necessitates a parallel evolution in postgraduate course teaching. Grounded in the Technology-Organization-Environment (TOE) framework, this study identifies critical practical challenges impeding this evolution, namely: the rigidities of traditional pedagogical models, the misalignment between technological tools and teaching objectives, and the lack of a cohesive digital ecosystem.

To address these challenges, we propose a multi-faceted transformation model focused on technology enablement, organizational restructuring, and environmental optimization. We outline several key initiatives that serve as effective pathways for implementation, including the adoption of low-code development platforms, the creation of flexible curriculum systems, the deployment of AI-human co-teaching models, and the cultivation of smart learning environments that merge physical and virtual elements. Ultimately, this study offers significant implications for practitioners and policymakers, providing a robust framework for advancing the digital and intelligent transformation of postgraduate teaching.

ACKNOWLEDGMENTS

This research is funded by the 2024 Sichuan Provincial Teaching Reform Project titled “Research on the Development Model for Digital Empowerment of Innovative Public Administration Graduate Students” (Grant No. YJGXM24-C140).

REFERENCES

[1] Cai, C. Conceptual Analysis of Digital Governance and Its Good Governance Logic [N]. Social Sciences in China Press, 2022, October 13, p.5.

[2] Cai, S., Gao, X., & Yao, H. Digital Empowerment of Postgraduate Education: A Student-Centered Path for High-Quality Development. Journal of Educational Academia, 2024, (11), 3–9+67. doi:10.16477/j.cnki.issn1674-2311.2024.11.010

[3] Chen, L. Application of Low-Code Technology in Educational Digital Transformation. Information Systems Engineering, 2025, (03), 55–58.

[4] Hao, J., & Guo, J. Implementation Logic of Intelligent Technology Empowering Precision Teaching. e-Education Research, 2022, 43(06), 122–128. doi:10.13811/j.cnki.eer.2022.06.016

[5] Li, S., & Han, Y. Field Transition, Rule Generation, and Path Adaptation of Teacher-Student Interaction in Digital Transformation. Teaching & Administration, 2025, (09), 61–66.

[6] Peng, B., & Wang, Z. Practical Challenges and Implementation Directions of Technical-Labor Education in Vocational Colleges under the TOE Framework. Education and Vocation, 2023, (01), 13–20. doi:10.13615/j.cnki.1004-3985.2023.01.014

[7] Zhang, L., & Gu, X. Factors Influencing AI Innovation Diffusion in Education: A TOE Framework Approach. Distance Education in China, 2023, 43(02), 54–63+82. doi:10.13541/j.cnki.chinade.2023.02.008

[8] Zhang, M., Jiang, Q., & Zhao, W. Digital Transformation Empowers High-Quality Development of Higher Education: Configuration Path Analysis Based on TOE Framework. e-Education Research, 2024, 45(03), 54–61. doi:10.13811/j.cnki.eer.2024.03.008

[9] Eveland, J., & Tornatzky, L. G. Technological Innovation as a Process. Publisher: Lexington Books, 1990, 27(50). https://doi.org/10.7251/emc2201237t