A Study on Collaborative Mechanisms for the Development of AI-Empowered Intelligent Teaching Resources in Vocational Education

A Comparative Multi-Case Analysis Based on Six Institutions

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ABSTRACT
Overcoming the challenges in the collaborative development of intelligent teaching resources for vocational education is a core priority for leveraging artificial intelligence to drive high-quality development in the sector. Drawing on stakeholder and collaborative governance theories, this paper establishes an "Actor-Process-Institution" analytical framework and conducts a multi-case study of six vocational schools across multiple regions. The study identifies six models of collaborative resource development, clarifies the closed-loop operational logic of resource development, and uncovers practical challenges such as an imbalance of rights and responsibilities between schools and enterprises, fragmented development processes, a lack of institutional safeguards, and insufficient effectiveness evaluation. Based on these findings, the paper proposes optimization strategies in four areas: building a collaborative ecosystem of diverse stakeholders, improving closed-loop development and operational processes, establishing a robust standard evaluation and assurance system, and constructing a multidimensional effectiveness indicator system. These strategies provide a theoretical foundation and practical guidance for the collaborative development of intelligent teaching resources in vocational education.

Keywords: *Vocational education, Intelligent teaching resources, Multi-stakeholder, Collaborative mechanisms, Industry-education integration.*

1. INTRODUCTION

1.1 Research Background and Problem Statement

The rapid evolution of artificial intelligence (AI) technology is reshaping the teaching models and resource delivery methods in vocational education. Education is moving toward a digital transformation, and the development of digital teaching resources can meet the need for personalized instruction[1].

According to the *Report on the Development of Artificial Intelligence Applications in Vocational Education (2024–2025)*, nearly 50% of higher vocational colleges nationwide have introduced general AI courses, 67.33% of institutions are experimenting with AI to enhance teaching efficiency, and 45.79% have developed digital resources[2]. At the 2025 World Digital Education Conference, case studies such as Wuhan Technical University's "Optoelectronics Education Large Model" and Wuhan City Polytechnic's AIGC digital teacher "Xiao Wu" were prominently showcased, reflecting that the application of AI technology in vocational education is shifting from "isolated exploration" to "systematic integration[3][4]."

However, against the dual backdrop of policy drivers and technological iteration, the development of intelligent teaching resources still faces deep-seated challenges. Currently, the development of digital teaching resources remains incomplete. Issues such as inconsistent quality, slow updates, and underutilization persist[5]. First, development mechanisms are fragmented; most institutions adopt a “project-driven, technology-first” model, lacking systematic needs analysis and efficient coordination mechanisms among government, industry, enterprises, and schools, resulting in a disconnect between resources and industrial demands. Second, the effectiveness of application is unclear. Although tools such as virtual simulation and intelligent assessment have emerged widely, there is a lack of scientific evaluation of their actual impact on students’ skill enhancement, with the problem of “emphasizing development, neglecting application, and struggling with evaluation” being particularly prominent. Third, industry-education collaboration is inefficient, with insufficient enthusiasm for corporate participation, stemming from the absence of a profit-sharing mechanism and excessively high transaction costs.

Based on this, this paper poses the core questions: How does the collaborative mechanism among multiple stakeholders function in the development of smart teaching resources for vocational education? What structural barriers exist, and how can they be optimized? Through a comparative analysis of multiple cases from six representative institutions, this study aims to provide theoretical support and practical guidance for establishing a sustainable mechanism for the development of intelligent teaching resources.

1.2 Research Approach and Case Selection

This study draws upon stakeholder theory[6](Freeman, 1984) and collaborative governance theory[7](Ansell & Gash, 2008) to construct a three-dimensional analytical framework comprising “actors, processes, and institutions.” The “Actor” dimension identifies five core stakeholders: government, industry, enterprises, institutions, and teachers; the “Process” dimension divides collaborative development into five stages: needs identification, collaborative design, technical implementation, quality assurance, and dynamic iteration; the “Institution” dimension examines the impact of formal institutions (policies, regulations, technical standards, and property rights arrangements) and informal institutions (organizational culture and trust relationships) on collaborative efficiency.(“Figure 1”)

Case selection followed the principles of theoretical sampling: (1) cases featuring typical and publicly available AI resource development practices; (2) cases covering different regions, including Central China, Southwest China, and East China; (3) cases encompassing both vocational bachelor’s degree programs and higher vocational college programs; (4) Specialized fields covering optoelectronic information, urban services, electronic information, food testing, power engineering, and information technology. Ultimately, six institutions were selected, with their basic information shown in “Table 1”. Data sources include publicly available institutional reports, policy documents, core journal articles, and authoritative media reports; all materials have undergone cross-verification.

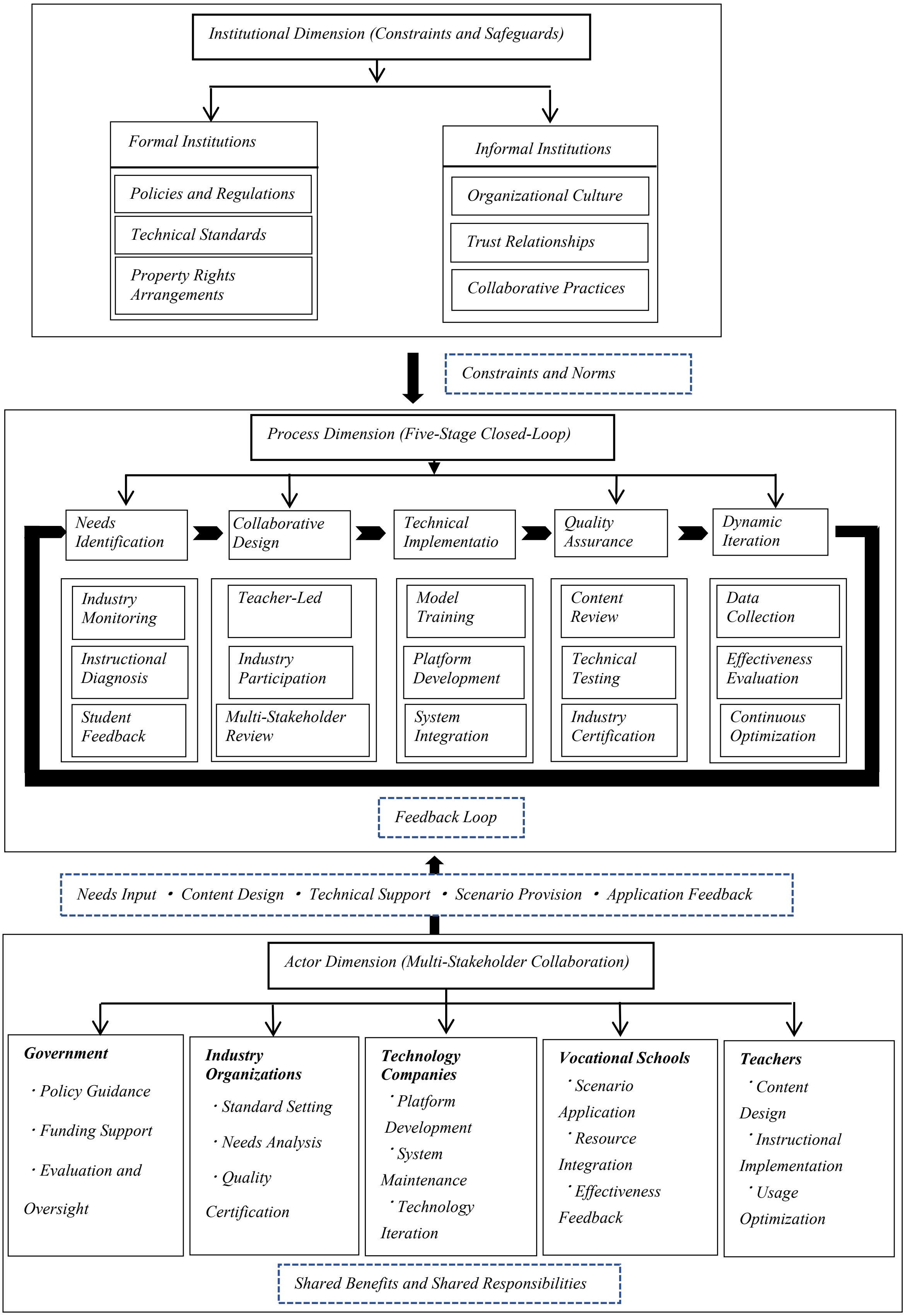

Figure 1 “Actor-Process-System” three-dimensional analytical framework.

Table 1. Basic Information on the Six Case Institutions

Institution Name	Region	Educational Level	Specialized Discipline Clusters	AI Resource Development Focus	Collaboration Model Type
Wuhan Technical University	Central China·Wuhan	Vocational Bachelor's	Optoelectronic Information	Optoelectronic Education Large Model	Discipline-Driven Large Model
Wuhan City Polytechnic	Central China·Wuhan	Vocational Associate Degree	Urban Services	AIGC Digital-Intelligent Teachers	Industry-Education Integration Platform
Chongqing Polytechnic University of Electronic Technology	Southwest China·Chongqing	Vocational Bachelor's	Electronic Information	"Digital-Intelligent Chongqing Electronics" Platform	Digital Ecosystem-Driven
Zhejiang Institute of Economics and Trade	East China·Hangzhou	Vocational Associate Degree	Food Testing	AI+Virtual-Physical Synergy System	Tripartite Collaboration Model
Guangxi Electrical Polytechnic Institute	Southwest China·Nanning	Vocational Associate Degree	Electric Power Engineering	Beidou+AI Digital Curriculum	Industry-Academy Collaboration Model
Beijing Information Technology College	North China·Beijing	Vocational Associate Degree	Information Technology	"Digital Brain" Platform	Data-Driven Model

2. CURRENT STATUS AND MODELS OF COLLABORATIVE DEVELOPMENT OF SMART TEACHING RESOURCES IN VOCATIONAL EDUCATION

2.1 The Current Landscape of Collaborative Development

Practices at the six institutions indicate that the development of smart teaching resources has shifted from independent development by individual institutions to collaborative participation by multiple stakeholders. The government primarily plays a role through policy guidance and project funding; industry organizations still show insufficient involvement in standard-setting and quality certification; technology companies have become the core driving force behind platform development and algorithmic support; vocational institutions, as providers of application scenarios, assume the roles of resource integration and effectiveness feedback; and teachers play a key role in content design and instructional implementation.

In terms of investment, all institutions have designated the development of intelligent resources as a key project during the 14th Five-Year Plan period, with annual investments ranging from several million to over ten million yuan. In terms of technological approaches, technologies such as large language models, knowledge graphs, virtual simulation, and learning analytics have been widely adopted. In terms of outcomes, metrics such as total resource volume, registered users, and traffic have shown significant growth, with some institutions having developed best practices that can be replicated and scaled.

Since the 12th Five-Year Plan period, vocational education has achieved some success in digital resource development; however, issues such as insufficient relevance of content, incomplete platform functionality, and inadequate application mechanisms persist. While individual issues can be attributed to problems with resource content, platform functionality, and development mechanisms, a broader analysis reveals a mismatch between project development and the "deep integration of technology and education" currently driving educational informatization—specifically, a lack of innovation in individual elements and insufficient synergy among them[8].

2.2 Comparison of Multi-Case Collaboration Models

Six institutions have developed six distinct collaboration models:

2.2.1 Discipline-based Large Model-Driven Model (Wuhan Technical University)

Located in China's Optics Valley, this university is a model institution for digital campus construction among vocational colleges designated by the Ministry of Education. In 2025, its "Optoelectronics Education Large Model" was showcased as a digital transformation case study at the World Digital Education Conference. Core Approaches: ① Established intelligent service platforms such as "Xiao Zhi Teacher" and "AI Guangling" to provide one-stop services for over 100 student affairs; ② Collaborated with iFlytek and Chaoxing to develop the "Chasing Light and Electricity" professional AI large model, which tracks real-time technological iterations within Optics Valley's "optics-chip-display-terminal-network" industrial cluster, with 37% of course content updated every six months; ③ Developed the "Learning Journey Navigation System" to visualize student development data and achieve 100% integration with the Ministry of Education's Vocational Education Brain. Collaborative Features: Using the specialized large model as a link, it directly maps industry chain technology dynamics into a curriculum competency map, forming a three-chain integration of "education chain—industry chain—technology chain[3]."

2.2.2 Industry-Education Integration Platform Model (Wuhan City Polytechnic)

The college is one of the first pilot institutions for the Ministry of Education's Digital Campus initiative. Its AIGC digital intelligent teacher "Xiao Wu," jointly developed by the School of Computer Science and Tencent Cloud, leverages tools such as Tencent's Hun Yuan large model and DeepSeek to interact in 10 languages, creating a full-cycle closed-loop system encompassing "in-class design — post-class guidance — project implementation". It has established the Kunpeng Industry College in collaboration with Huawei, the nation's first "Embodied Robot Data Collection Training Center" for higher vocational education in partnership with Zhiyuan Innovation, and an AI+XR virtual-reality integrated training system with Suiguang Technology. Collaborative Features: Driven by AIGC technology, it constructs an industry-education integration paradigm characterized by "AI empowerment and four real elements driving industry" (real tools, real technology, real scenarios, and real demands)[4].

2.2.3 Digital Ecosystem-Driven Model (Chongqing Polytechnic University of Electronic Technology)

The university was upgraded to a vocational undergraduate institution in 2024, and its smart campus development received an A-level rating from the Ministry of Education. It has established 215 digital application scenarios with a 100% data sharing rate. Specific practices include: ① The "Smart Ideological and Political Education" big data platform breaks down educational evaluation into 18 quantifiable indicators and was selected as an outstanding case study in smart education by the Ministry of Education; ② The "AI + Big Data Student Evaluation Platform" constructs a comprehensive profile of students' development across all five educational dimensions, enabling longitudinal evaluation throughout the entire process and horizontal evaluation of all elements; ③ In collaboration with ZTE, the university developed the MOOC "5G Mobile Communication Technology," which has reached six Southeast Asian countries and achieved an 85% course engagement rate. Collaborative Features: With the university's data center as the hub, it achieves comprehensive digital collaboration across teaching, administration, ideological and political education, and internationalization.

2.2.4 Tripartite Collaboration Model (Zhejiang Institute of Economics and Trade)

The college's Food Testing program has established an "AI + Virtual-Physical Synergy" teaching system, integrating AI models, XR devices, and knowledge graphs. It adopts a tripartite workshop model involving "subject faculty—industry engineers—technical development teams," with joint design iterations conducted weekly. Post-implementation, report accuracy reached 98.2%, and equipment maintenance costs decreased by 57%.

2.2.5 Industry College-Driven Model (Guangxi Electrical Polytechnic Institute)

The college has established an industry college in collaboration with Beidou enterprises, forming a three-tiered interactive framework of "industry college—specialty clusters—enterprise-sponsored classes" to promote the integration of the education chain, industrial chain, innovation chain, and employment chain. The rate of students securing jobs in their field of study increased by 25%, with an 88% satisfaction rate among enterprises.

2.2.6 Data-Driven Model (Beijing Information Technology College)

The college has established a "Digital Brain" platform to integrate all internal data and utilize learning analytics technology to enable targeted recommendations and intelligent monitoring. Instructors optimize instructional design based on platform feedback, resulting in a 20% increase in student learning efficiency.

Comparative analysis reveals that the effectiveness of the collaborative model depends on the completeness of these five stages. Among them, the most effective methods for identifying needs are "industry data-driven" and "automatic data collection"; the sustainability of dynamic iteration hinges on the ability to close the data loop; and the level of systematization in quality assurance is positively correlated with the efficiency of resource utilization.

When collaborative development is divided into five key stages, significant performance differences emerge among the six institutions ("Table 2").

Table 2. Comparison of the Completion Levels of Collaborative Processes Across Six Institutions

Stage	Wuhan Technical University	Wuhan City Polytechnic	Chongqing Polytechnic University of Electronic Technology	Zhejiang Institute of Economics and Trade	Guangxi Electrical Polytechnic Institute	Beijing Information Technology College
Requirement Identification	Industry Data-Driven	Joint School-Enterprise Research	Automated Data Collection	Workshop-Based Requirements	Industry Reports	Platform Logs
Collaborative Design	Tripartite Participation	Deep Team Integration	Multi-department Collaboration	Faculty-Engineer Technical Collaboration	Coordination by Industry-Academic College	Data Function Team
Technical Implementation	In-house R&D + Enterprise	Enterprise-led	In-house R&D-led	Enterprise-led	University-Enterprise Joint Development	In-house R&D
Quality Assurance	Systematic	Systematic	Systematic	Partial	Partial	Systematic
Dynamic Iteration	Data Closed-loop	Feedback Optimization	Data Closed-loop	Manual Feedback	Manual Feedback	Data Closed-loop

3. CAUSES OF OBSTACLES TO MULTI-STAKEHOLDER COLLABORATIVE DEVELOPMENT

3.1 Imbalance in the Powers and Responsibilities of Key Stakeholders

An analysis of the five types of stakeholders using the power-interest matrix reveals that technology companies and vocational colleges belong to the "high interest—medium-high power" group and serve as the core drivers of collaboration. However, companies hold relatively less power than colleges, and their economic returns lack institutional safeguards, leading to a situation where "colleges are enthusiastic while companies are lukewarm." The government possesses high power but has moderate interest in the matter; it tends to guide development through policy rather than direct participation, and standard-setting lags behind practical needs. Industry organizations fall into the "medium-high power—medium interest" quadrant; they have weak standard certification capabilities and are noticeably absent from the process. Teachers have the lowest power but the highest level of interest; the depth of their participation directly determines the suitability of resources for teaching, yet existing incentives are severely inadequate, leaving them overworked and underappreciated.

3.2 Disruptions in the Development Process

When collaborative development is divided into five key stages, significant performance disparities emerge among the six institutions. Most institutions experience disruptions in the "quality assurance" and "dynamic iteration" stages. Regarding quality assurance, only Wuhan Vocational University, Chongqing Open University, and Beijing University of Information Technology have established systematic tripartite review mechanisms involving “content, technology, and industry”; other institutions consider resources usable merely upon project acceptance, lacking continuous quality monitoring after launch. In terms of dynamic iteration, institutions relying on data-driven feedback loops can optimize resources weekly or monthly, whereas those relying on manual feedback may update only once per semester, leading to a disconnect between resource content and industrial technology.

3.3 Lack of Institutional Safeguards

Absence of standards. At the national level, no functional specifications, data interface standards, or content rating certification methods for smart teaching resources have yet been established. Resource formats from different institutions and companies are incompatible, leading to redundant development and hindering the cross-institutional sharing of high-quality resources[1].

3.4 Lack of Effectiveness Evaluation

Most institutions view resource development as merely “completing a project” and lack effectiveness evaluations grounded in educational measurement. Only a few institutions have conducted systematic learning data analysis, but they have yet to establish causal inference models linking resource usage to skill improvement. The absence of effectiveness evaluation leaves resource iteration directionless and makes it difficult for institutions to secure sustained funding based on empirical data, creating a vicious cycle characterized by “overemphasis on development, neglect of application, and difficulty in evaluation.”

4. PATHWAYS FOR OPTIMIZING AI-EMPOWERED COLLABORATION MECHANISMS

4.1 Building a Multi-Stakeholder Collaborative Ecosystem

To address the imbalance in the rights and responsibilities of stakeholders, efforts should begin with the definition of property rights and the establishment of profit-sharing mechanisms. First, it is to adopt the principle of “categorized rights confirmation and profit sharing”: resources generated by government funding should be made available for open sharing on a public platform; enterprises should enjoy profit rights in proportion to their technological contributions; and faculty members may retain intellectual property rights for their original resources, which can also be used as achievements in professional title evaluations. Second, it is to promote the institutionalization of industry-academic colleges, clarifying equity and profit distribution among all parties through corporate bylaws. Third, it is to explore blockchain-enabled smart contracts to achieve automatic measurement of resource usage and automatic distribution of returns, thereby reducing transaction costs. At the same time, it is necessary to strengthen the leading role of industry organizations in standard-setting and quality certification, and enhance institutional incentives for faculty participation.

4.2 Improving the Closed-Loop Development and Operation Process

To address process disconnects, a mandatory “three-review, three-proofreading” system should be established: content experts review pedagogical suitability, technical experts review functional specifications, and industry experts review alignment with occupational standards. Drawing on the experience of Wuhan Vocational College’s “Learning Pathway Navigation System”, a university-level data middle platform should be built to enable automatic collection and analysis of learning behavior data, compressing the resource iteration cycle to monthly updates. Establish dedicated positions for resource effectiveness evaluation, regularly publish evaluation reports, and make anonymized data publicly available to compel developers to continuously optimize their work. By leveraging this data-driven closed-loop system, integrate the entire chain—from “needs identification, collaborative design, technical implementation, quality assurance, to dynamic iteration”—to create a virtuous cycle.

4.3 Improving the Standard Evaluation and Support System

To address the issues of missing standards and inadequate evaluation, efforts should focus on three areas. Systematization of standards: Led by the Education Management Information Center of the Ministry of Education, develop the *Technical Specifications for the Development of Intelligent Teaching Resources in Vocational Education* to clarify functional requirements, data interfaces, and security standards; establish a three-tier quality certification system comprising “developer self-assessment—institutional review—third-party certification”[1]; and promote the standardization of resource formats to achieve cross-platform interoperability.

4.4 Establishing a Multi-Dimensional Performance Indicator System

There is a must to construct a four-tier evaluation indicator system encompassing “resource utilization rate → learner satisfaction → skill improvement → employment competitiveness,” incorporating a learning gain model; encourage quasi-experimental studies to compare differences between classes using and not using smart resources; and use evaluation results as the core basis for funding allocation and resource recommendations.

5. CONCLUSION

The "Strategic Action Plan for the Digitalization of Vocational Education" explicitly calls for the establishment of an interconnected, collaborative, and shared digital resource system for vocational education to support its high-quality development[9]. Resources, platforms, and mechanisms are the three core elements of resource development and application. Promoting the collaborative development of intelligent teaching resources is a key measure for implementing the digital transformation of education and strengthening the substantive development of vocational education. Supporting the agile evolution of system functions through open platform architectures, and empowering decision-making and human-machine collaboration through data to provide comprehensive, demand-driven services for the education sector, will be the focus of future educational development[10].

Based on a comparative analysis of multiple cases from six representative institutions, this study systematically clarifies the collaborative models, constraint mechanisms, and optimization pathways for the development of intelligent teaching resources. It elucidates the core roles of the five stages—"demand identification—collaborative design—technical implementation—quality assurance — dynamic iteration," revealing the deep-seated constraints arising from imbalances in the power and interests of key stakeholders. It proposes a four-dimensional optimization strategy encompassing property rights, standards, processes, and evaluation, offering a systematic approach to resolving collaborative dilemmas.

From a theoretical perspective, this study integrates stakeholder theory and collaborative governance theory into research on intelligent resources for vocational education, constructing a targeted analytical framework that enriches the theoretical foundation of digital governance in vocational education. At the practical level, it distills replicable collaborative models, providing actionable references for institutions of various types and helping to address industry pain points such as resource homogenization and inefficient collaboration.

Although this study has made some progress, there are still shortcomings in terms of sample coverage, data richness, and longitudinal tracking. In the future, we can further expand the scope of case studies, deepen the integration of methodologies, and incorporate multidisciplinary perspectives. We will continue to focus on ethical issues in the application of AI technology and continuously improve the collaborative governance system for intelligent teaching resources, thereby providing solid support for the digital transformation and upgrading of vocational education and the development of a sustainable resource ecosystem.

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