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THE CONSTRUCTION OF DIGITAL GOVERNANCE ECOSYSTEM MODEL FOR DIGITAL TRANSFORMATION OF VOCATIONAL EDUCATION

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Abstract: Under the impact of the digital economy wave, the digital transformation of vocational education has become an inevitable trend of the times. However, the current problems such as technological fragmentation, low collaboration efficiency, and rigid data barriers have seriously hindered its development process. This study organically integrates ecological theory with the concept of digital governance, and constructs an innovative three-level progressive model of "Basic Support - Core Collaboration - Goal Achievement". Adopting a pyramid - shaped structure, this model effectively integrates multiple subjects and digital technology resources, and realizes the collaborative governance of the tripartite subjects (government, schools, and enterprises) with the help of four operating mechanisms. Focusing on solving the problem of "data silos", this model is committed to promoting in - depth sharing of industry - education data and facilitating the practical application of virtual training scenarios, thus providing a set of solutions with both theoretical depth and practical guiding significance for the digital transformation of vocational education.
Keywords: Vocational education; Digital transformation; Digital governance ecosystem; Model construction; Industry-Education integration; Tripartite collaboration

1 INTRODUCTION

Against the background of digital technology reshaping the industrial structure, the theory and practice of digital transformation in vocational education have become the focus of attention. From the perspective of technology empowerment, the iteration of emerging technologies such as artificial intelligence and big data has promoted the global industry towards digital and intelligent development. The digital economy has become the core driving force for economic growth, which puts forward higher requirements for the digital literacy, multi - scenario practical ability, and innovative thinking of technical and skilled talents. The digital transformation of vocational education directly affects the adaptation degree between talent supply and industrial demand [1].

From an international comparison perspective, Germany has built a digital training system with in - depth collaboration between enterprises and colleges relying on Industry 4.0, integrating technologies such as industrial Internet of Things into teaching to meet industrial needs. The United States has built a national digital resource sharing platform by virtue of the "National Vocational Education Technology Plan", forming a mechanism for resource integration and capacity co - construction, which provides a reference for China [2]. Looking back at China, although vocational education digitalization has achieved remarkable results in curriculum resource development and teaching model innovation, there are still structural contradictions in systematic governance, such as the superficial application of digital technology, the imperfect collaborative mechanism of multiple subjects, and the need to improve the unified digital governance ecosystem framework. In view of this, this study focuses on the theoretical construction of the digital governance ecosystem of vocational education, aiming to make up for the research limitations of focusing on technology application while neglecting ecosystem construction, provide an innovative path to solve the dilemmas such as governance fragmentation and imbalance between industry - education supply and demand, and contribute to the high - quality development of vocational education.

2 THEORETICAL BASIS

2.1 Connotation and Characteristics of Digital Transformation in Vocational Education

The digital transformation of vocational education is not a simple combination of technology and education, but a process of overall deconstruction and reconstruction of the vocational education system with digital technology as the core driving force. According to the theory of educational digital transformation, its essence is to use digital technology to break the limitations of time and space, optimize the allocation of educational resources driven by data, promote the transformation of vocational education from a supply - oriented model to a learner - centered one, and then cultivate high - quality technical and skilled talents suitable for the digital economy [1].

From an academic perspective, this transformation has four characteristics. First, systematicness and comprehensiveness, which covers the whole life cycle of curriculum development, teaching implementation, evaluation and feedback, and management services, and builds a closed - loop digital ecosystem. Second, innovation and

disruption, which rely on technologies such as VR and AI to give birth to new educational forms such as virtual simulation training and intelligent tutoring, and realize the innovation of teaching models. Third, dynamics and adaptability, which require continuous updating of teaching resources and talent training programs with the iteration of technology and industrial upgrading. Fourth, collaboration and openness, which emphasize that multiple subjects such as the government, colleges, and enterprises should break down boundaries and build a co - construction and co - governance digital governance pattern through data sharing and business collaboration [1].

2.2 Theories Related to Digital Governance Ecosystem

The digital governance ecosystem theory is the cross - product of ecosystem theory and digital governance theory. It decomposes the governance system into a three - dimensional coupled whole of subjects, technologies, and environment. Various elements achieve dynamic balance and collaborative evolution through material circulation, energy conversion, and information transmission. In the field of vocational education, the subject dimension is composed of the government, enterprises, colleges, teachers, and students to form an interactive network like a biological community [3]; the technology dimension is composed of big data, AI, blockchain, and other technologies to form technical infrastructure [4]; the environment dimension relies on policies and regulations, standards and norms, and social atmosphere to provide institutional guarantees and participation motivation. The practical essence of digital governance ecosystem in vocational education is to use digital technology to reconstruct governance processes, build a data - driven decision - making mechanism, break down barriers through data sharing, tap value through data analysis, and inject new impetus into the high - quality development of vocational education.

2.3 Interactive Relationship between Digital Transformation of Vocational Education and Digital Governance Ecosystem

The digital transformation of vocational education and the digital governance ecosystem present a collaborative evolution relationship of two - way empowerment, forming a spiral upward model through the coupling mechanism of technical support and institutional feedback. The digital transformation relies on new infrastructure such as intelligent teaching platforms and virtual training bases to build a technical carrier for multi - subject collaboration. At the same time, it promotes colleges and enterprises to break through the collaboration boundaries, reshape the relationship of rights, responsibilities, and interests, and expand the application field of the governance ecosystem. The digital governance ecosystem uses standardized systems and mechanism innovation to balance the interests of subjects, solve the transformation problems such as data barriers, and its dynamic adaptive characteristics are connected with technology iteration and industrial upgrading, providing sustainable momentum for the transformation [1].

3 CURRENT SITUATION AND PROBLEMS OF DIGITAL TRANSFORMATION IN VOCATIONAL EDUCATION

3.1 Current Situation of Digital Transformation in Vocational Education

The digital transformation of vocational education has achieved remarkable results in the field of infrastructure construction. By continuously promoting the transformation strategy, a three - dimensional and multi - level infrastructure support system has been built, which has laid a solid material foundation for the innovation of educational and teaching models [5]. From the perspective of network communication architecture, the vast majority of vocational colleges across the country have achieved full coverage of wired and wireless networks on campus. By deploying backbone networks, they ensure the stable operation of teaching applications with high bandwidth requirements such as high - definition video teaching and virtual simulation training, and avoid the impact of network problems on teaching effectiveness. In terms of hardware equipment configuration, intelligent interactive display terminals and teaching video recording systems have become standard teaching equipment in colleges, which can meet the daily needs of digital teaching. Some leading vocational colleges have further built new teaching spaces such as VR/AR immersive training laboratories and AI teaching quality diagnosis and analysis centers, creating innovative demonstration samples of digital teaching environments [6].

The digital construction of vocational education has also achieved remarkable results in the application of resources and technologies, promoting teaching innovation in multiple dimensions. At present, a three - level vocational education digital resource system (national, provincial, and college levels) has been formed, and a three - dimensional resource matrix centered on courseware development, virtual simulation experiments, industry typical case database construction, and assessment question bank design has been built to provide rich materials for teaching. Various vocational colleges actively develop school - based digital resources in combination with the needs of regional industrial development and their own professional characteristics. By introducing cutting - edge technologies such as virtual reality and artificial intelligence, they effectively break the limitations of traditional training equipment in time, space, and functions, and solve the problems in practical training [7]. At the same time, the online - offline hybrid teaching model is widely used. Most colleges deeply integrate digital resources into the curriculum teaching system, realizing the vertical deepening and horizontal expansion of teaching content, and significantly enhancing the pertinence and effectiveness of vocational education and teaching [8].

Under the in - depth penetration of digital technology, the teaching model of vocational education has undergone an all - round and systematic transformation, showing distinct digital characteristics. Relying on the empowerment of digital technology, the teaching model has achieved systematic innovation. In the field of complex practical operations, virtual simulation teaching has become an important teaching model due to its high simulation degree and strong interactivity. Digital twin technology provides support for the integration of theory and practice teaching, promoting the in - depth integration of theoretical knowledge and practical operations [9]. In addition, teaching methods such as project - based learning and inquiry - based learning are deeply combined with digital technology to build a new student - centered teaching system. Teachers can also use big data analysis technology to deeply analyze the characteristics of students' learning behaviors, establish personalized learning models, and accurately push learning tasks, thus effectively improving the targeting and effectiveness of teaching.

3.2 Problems Faced by the Digital Transformation of Vocational Education

3.2.1 Application of digital technology: coexistence of superficialization and fragmentation

Although digital technology has been integrated into vocational education, there are still obvious bottlenecks in the depth and breadth of application. In teaching practice, most teachers only use digital technology for superficial assistance such as PPT demonstrations and video playback, and there is insufficient in - depth application of cutting - edge technologies such as artificial intelligence learning situation analysis, big data teaching diagnosis, and virtual reality training. In the field of management, digital technology does not cover the whole life cycle of enrollment, teaching, and employment, and fails to form a closed - loop management system for data collection, analysis, decision - making, and feedback [10]. In addition, the application of technology is fragmented. The procurement of digital tools by various departments and majors lacks top - level coordination, resulting in prominent problems of repeated construction and resource mismatch, which restricts the overall improvement of teaching efficiency.

3.2.2 Digital literacy of teachers and students: disconnection between basic abilities and high - level needs

The structural shortage of digital literacy of teachers and students has become a core problem restricting the in - depth development of the digital transformation of vocational education. From the perspective of teachers, most teachers lack the ability in the development of virtual simulation courses, the integration of multi - modal resources, and the application of intelligent tools, making it difficult for them to design digital teaching projects that are deeply integrated into the real application scenarios of the industry. Some senior teachers have weak adaptability to digital technology and show a tendency of technology use anxiety. Their willingness to actively explore emerging digital technologies and their ability to transform them into practice in the process of professional development need to be improved. From the perspective of students, although the new generation of learners shows a high degree of proficiency in the operation of basic digital tools, there is an obvious ability gap in the high - level application fields of digital technology such as data modeling and analysis, algorithm thinking construction, and information security protection. This lack of ability directly limits their ability to independently carry out practical innovation projects based on industry big data. In addition, the management of colleges generally has the phenomenon of superficial use of digital governance tools, mainly applying them to basic functions such as data statistics, and failing to give full play to the core value of the data center in optimizing teaching decisions and intelligently allocating educational resources [11].

3.2.3 Digital governance mechanism: lack of standards and low collaboration efficiency

The lack of a standardized system is a key constraint factor in the construction of the digital governance system of vocational education. At present, there is no unified national technical standard and standard system, which leads to significant differences in the format coding and storage protocols of digital resources among vocational colleges. The interface compatibility between information system platforms is insufficient, which ultimately leads to data interaction barriers and the typical phenomenon of "data silos", hindering the interconnection of resources across colleges and regions. In the construction of the multi - collaborative governance mechanism, the division of rights and responsibilities among the government, enterprises, and vocational colleges lacks a clear institutional definition. Enterprises are cautious about the opening and sharing of production and operation data due to the protection of intellectual property rights and commercial competition, and the provision of core data to colleges is not ideal. Vocational colleges have obvious deficiencies in the construction of standardized collection, professional analysis, and feedback paths of talent training quality evaluation data, and fail to establish a standardized and efficient data transmission channel, resulting in the disconnection of data between the industry and education sectors. In addition, the construction of the data security governance system is obviously lagging behind. Most vocational colleges have not built a perfect framework for the classified and hierarchical management system of teaching data, and there are institutional gaps in key technical links such as sensitive information encryption and protection of teachers' and students' privacy. This leads to systematic security risks such as data leakage and abuse in business scenarios such as the collection of teachers' and students' personal information and the storage and management of teaching process data [12-13].

3.2.4 Digitalization of industry - education integration: superficial cooperation and resource disconnection

The endogenous driving force of enterprises to participate in the digital transformation of vocational education is obviously insufficient. At present, the school - enterprise cooperation model mostly stays at the superficial level of affairs such as equipment donation and internship base licensing. In the core fields such as the collaborative development of digital education resources and the joint design of talent training systems, the participation of enterprises and the investment of resources are insufficient [14]. From a deeper perspective, there is no perfect

collaborative sharing mechanism for school - enterprise digital resources. The high - quality digital production resources accumulated by enterprises lack a transformation path suitable for teaching and are difficult to integrate into the classroom. However, the virtual simulation courses and digital teaching materials independently developed by colleges are often disconnected from the actual production scenarios of enterprises because they are not connected to the latest production processes and industry standards of enterprises, resulting in the limited practical value of these teaching resources in cultivating students' post - adaptation ability. The lack of synergy efficiency of industry - education resources directly leads to a structural mismatch between the digital skills training standards of vocational college graduates and the actual needs of the industry, forming an obvious talent supply gap and restricting the core role of the digital transformation of vocational education in serving industrial development.

4 CONSTRUCTION OF DIGITAL GOVERNANCE ECOSYSTEM MODEL FOR VOCATIONAL EDUCATION

4.1 Overall Structure of the Model

Based on the ecosystem theory and the digital governance theory framework, this study innovatively constructs a pyramid - shaped digital governance ecosystem model for vocational education, which includes three parts: basic support, core collaboration, and goal achievement. This model follows the logical closed - loop of technology empowering subjects, subjects co - constructing the environment, and the environment feeding back development.

The model systematically integrates three core components: the basic support layer, the core collaboration layer, and the goal achievement layer. The basic support layer is composed of digital infrastructure (hardware facilities and digital platforms) and an environmental guarantee system (policies and regulations, standards and norms), providing material foundations and institutional guarantees for the operation of the model. The core collaboration layer integrates multiple governance subjects such as government departments, industry enterprises, vocational colleges, teachers, and students, and combines digital governance tools such as big data analysis, artificial intelligence algorithms, and blockchain technology to maximize governance efficiency through collaborative linkage among subjects and technology empowerment. The goal achievement layer takes the cultivation of high - skilled talents who meet the development needs of the digital economy as the core goal, promotes the transformation and upgrading of vocational education towards intelligence, personalization, and precision, and realizes the in - depth coupling between the improvement of education quality and the demand for industrial talents. Relying on four operating mechanisms (collaborative cooperation mechanism, data circulation mechanism, incentive and constraint mechanism, and innovation and evolution mechanism), the model builds a dynamically balanced ecosystem, aiming to solve the practical dilemmas such as governance fragmentation and the mismatch between industry - education supply and demand in the process of digital transformation of vocational education.

4.2 Model Structure Design: Pyramid - shaped Hierarchical Structure

4.2.1 Bottom layer: the basic support layer lays a solid foundation for the operation of the ecosystem

The basic support layer is the hardware base and institutional guarantee for the operation of the model, which mainly covers two core dimensions: the construction of digital infrastructure and the construction of environmental guarantee elements. In terms of digital infrastructure, by building hardware such as campus 10 - gigabit backbone networks, deploying intelligent interactive terminals, and constructing virtual simulation laboratories, a unified cloud computing platform and Internet of Things environment are built simultaneously to realize the real - time transmission and storage of teaching and training data. At the same time, relying on the data center, it provides full - process technical support for data collection, processing, analysis, and application, forming a closed - loop system. In the construction of environmental guarantee elements, a institutional framework is formulated with policies and regulations, standards and norms as the core. Policies and regulations are improved to clarify the boundaries of rights and responsibilities and behavioral norms of various subjects in the ecosystem. The standard and normative system is improved to ensure the standardized operation and interconnection of various components, laying a solid institutional foundation for the stable operation of the digital governance ecosystem model of vocational education.

4.2.2 Middle layer: the core collaboration layer builds a multi - linkage pattern

The core collaboration layer is the core driving mechanism for the operation of the model. It builds a systematic collaborative governance structure through the in - depth integration of multiple governance subjects and digital technology systems. In terms of multi - subject collaboration, a governance system with clear rights and responsibilities is formed. The government is responsible for policy planning, resource allocation, and performance evaluation. Enterprises undertake technology supply, industrial demand transmission, and practical resource construction. Colleges focus on the construction of teaching systems, curriculum development, and talent training. Teachers carry out digital teaching innovation and student guidance. Students complete the internalization of knowledge and skills through independent learning and practice. In terms of the digital technology empowerment path, big data analysis is used to carry out learning situation diagnosis, teaching evaluation, and talent demand forecasting. Artificial intelligence is used to develop intelligent teaching assistance systems and personalized learning platforms. Blockchain is used to build a trusted data certification and sharing mechanism. Virtual reality is used to create high - simulation training environments. At the same time, through the construction of cross - departmental data centers, the integration and sharing of multi - source heterogeneous data are realized, and the information barriers among subjects are broken.

4.2.3 Top layer: the goal achievement layer focuses on the core of talent training

The goal achievement layer is the value - oriented dimension of the model operation, and its core goal system covers two key aspects: talent training and education innovation. The talent training dimension focuses on cultivating compound high - skilled talents who have both professional theories, practical skills, and data thinking, algorithm application capabilities, and information security awareness. By connecting with the talent needs of core industries in the digital economy such as intelligent manufacturing and artificial intelligence, a precise education mechanism for industry - education collaboration is built. The education innovation dimension relies on the collaborative linkage between the underlying facilities and the middle - layer subjects to promote the implementation of innovative application scenarios such as the construction of virtual simulation teaching environments, real - time sharing of industry - education data, the construction of intelligent teaching evaluation, and the planning of AI personalized learning paths. It drives the transformation of vocational education from the traditional model to an intelligent,personalized, and precise model, and finally achieves the dual goals of comprehensively improving vocational education quality and dynamically adapting to industrial talent needs.

4.3 Model Element Composition: A Tripartite Ecosystem

4.3.1 Subject elements: multi - collaborative governance participants

Subject elements are the core actors in the digital governance ecosystem, consisting of five types of subjects: the government, enterprises, vocational colleges, teachers, and students. Each subject has a clear functional positioning and close interactive connections in the ecosystem. The government undertakes the functions of policy formulation, resource coordination, and supervision and evaluation. It regulates the operation of the system by issuing special policies for digital transformation, building a financial support system, and establishing a multi - dimensional evaluation index system. At the same time, as an organizer of cross - departmental and cross - regional coordination mechanisms, it is responsible for coordinating the interests of multiple subjects and promoting the collaborative development of the ecosystem. Enterprises assume important roles in technology empowerment, demand transmission, and practical support. Relying on their industrial advantages, they provide real industrial demand data and production scenario resources for the ecosystem, deeply participate in curriculum development and training base construction, and build an industry - education integration practice platform. By accepting students for internships and employment, they establish a talent quality feedback mechanism to provide a basis for optimizing talent training programs. Vocational colleges, as the main positions for talent training, focus on the construction of talent training systems, curriculum resource development, and teaching model innovation. They build intelligent teaching platforms, develop school - based digital resource libraries, implement mixed teaching and virtual simulation training, and establish a dynamic adjustment mechanism to ensure the accurate connection between talent training and industrial needs. Teachers assume key responsibilities in teaching implementation, resource integration, and learning guidance in the teaching process. They design project - based digital teaching plans, use intelligent teaching tools to carry out differentiated teaching, organize students to conduct digital skill practices, and optimize teaching strategies based on teaching practice feedback. As the terminal output subject of the ecosystem, students complete the acquisition of knowledge, improvement of skills, and transformation of abilities through participating in digital learning and practical projects. They feedback learning needs and experiences to form a positive cycle of teaching and learning, and eventually grow into high - quality skilled talents who adapt to the development of the digital economy.

4.3.2 Technical elements: core driving force for ecosystem operation

Technical elements are the core link connecting subjects and the environment in the vocational education digital governance ecosystem. Their essence is to realize the reconstruction of governance processes and the innovation of collaborative mechanisms through digital technology empowerment. The system includes seven core technology groups. Big data technology completes the collection, storage, and mining of multi - source heterogeneous data relying on the ETL (Extract, Transform, Load) process, and provides data support for governance decisions through data modeling and visual analysis. Artificial intelligence technology builds an intelligent decision - support system based on machine learning and natural language processing to realize risk early warning, trend prediction, and decision - making deduction. Cloud computing technology builds a dynamically scalable computing resource pool with a distributed architecture and virtualization technology to ensure the efficient and stable operation of the governance platform. Internet of Things technology realizes the interconnection between the physical space and the digital space according to the M2M (Machine - to - Machine) protocol, and builds a governance scenario with real - time perception and intelligent response. Blockchain technology builds a trusted data sharing and collaborative governance mechanism through distributed ledgers, consensus mechanisms, and asymmetric encryption algorithms. 5G technology supports the real - time transmission of governance data and edge computing with its high - bandwidth, low - latency, and wide - connection characteristics. Digital twin technology realizes the digital mapping and dynamic optimization of governance processes with the help of multi - physical field modeling and simulation optimization technology.

4.3.3 Environmental elements: guarantee for the stable operation of the ecosystem

Environmental elements are the core support of the vocational education digital governance ecosystem, and a institutional guarantee system and cultural ecosystem need to be constructed from three dimensions: policies and regulations, standards and norms, and social culture. In the dimension of policies and regulations, the government plans the transformation path by issuing special policy documents such as the "Vocational Education Digital Transformation Action Plan" and provides institutional guarantees for data security by formulating regulations such as the "Vocational

College Teaching Data Protection Regulations". In the dimension of standards and norms, the national unified digital standard system clarifies norms from aspects such as resource management, technology application, and process optimization, eliminates data barriers, and realizes the interconnection and collaborative sharing of educational resources across platforms. In the dimension of social culture, relying on multiple channels such as media communication matrices and academic discussion platforms, the public's awareness of the digital transformation of vocational education is continuously deepened. Through building practical innovation platforms to display digital achievements, a cultural ecosystem that values digital literacy cultivation and encourages collaborative innovation is cultivated, providing a sustainable social and cultural foundation for the digital transformation of vocational education.

4.4 Operation Mechanism: A Dynamically Collaborative Ecosystem Driving System

4.4.1 Collaborative cooperation mechanism: building a multi - subject co - governance pattern

With the core concept of "benefit sharing and responsibility sharing", a tripartite collaborative governance alliance structure of "government - enterprise - college" is constructed, and the specific implementation is carried out through the following paths. Promote the construction of a substantive collaborative platform, build an industry - education integration council governance system composed of government education authorities, representatives of leading enterprises in the industry, and heads of key vocational colleges, establish a quarterly joint meeting system, promote the joint construction and sharing of digital education resources, and the collaborative construction of training bases. At the same time, set up a school - enterprise special workshop to jointly develop digital talent training programs in key professional fields to solve the structural contradiction between the curriculum system and industrial needs. Construct a rights, responsibilities, and interests distribution mechanism, clarify the rights and responsibilities boundaries of the government, enterprises, and colleges through multi-party cooperation agreements, and establish a multi - dimensional benefit sharing mechanism at the same time.

4.4.2 Data flow and sharing mechanism: realizing two - way connection of industry - education data

Relying on a unified data center and blockchain technology, a full - process data governance system of "collection - cleaning - sharing - application" is constructed. In terms of data collection and standardization, the "Vocational Education Data Collection Specification" is formulated to clarify the scope of data collection for college teaching and enterprise industry. Multi - source heterogeneous data is intelligently collected through the data center, and data quality is guaranteed through the processing of cleaning algorithms and desensitization technology. In terms of data security sharing mechanism, an industry - education integration alliance chain is built based on blockchain, and the mode of "data on - chain without desensitization and authorized use with traceability" is adopted to open non - core production data. A data classification and grading system (public level, internal level, and confidential level) is established, and supporting access control strategies are matched to strengthen security protection. In terms of data application and closed - loop optimization, a big data platform is used to analyze talent training and industrial demand data, providing a basis for enterprises to optimize post standards and colleges to adjust professional courses, and forming a "data - driven - dynamic optimization" governance closed loop.

4.4.3 Incentive and constraint mechanism: stimulating the participation motivation of ecosystem subjects

A dual collaborative governance mechanism of "positive incentive - bottom - line constraint" is constructed, and institutional design is used to guide multiple subjects to participate in compliance and empower actively. In terms of the incentive mechanism, the government sets up a special financial incentive fund for the digital transformation of vocational education, and implements differentiated subsidies for core fields such as the construction of virtual simulation training bases in vocational colleges. A tax preferential system for enterprises to participate in school - enterprise cooperation is established, and the digital participation of enterprises is included in the selection and evaluation indicators of government projects. Colleges build a teacher development evaluation system oriented to digital capabilities, include digital teaching design in professional title evaluation, establish an incentive mechanism based on digital skill output, give performance bonuses to excellent teachers, and set up a stepped digital skill scholarship at the same time, stimulating students' motivation through systems such as credit replacement. In terms of the constraint mechanism design, an independent third-party evaluation system is constructed, an evaluation index matrix is established from three dimensions including policy implementation validity, dynamic assessment and closed - loop management are implemented; the "Vocational Education Digital Governance Compliance Operation Guide" is formulated, a negative behavior list is established, and a hierarchical punishment mechanism including risk early warning and interview rectification is constructed for violations such as delayed data sharing to ensure the orderly operation of the ecosystem.

4.4.4 Innovation and development mechanism: promoting the iterative upgrading of the ecosystem

A three - stage evolution mechanism of "pilot - promotion - iteration" is constructed to realize the coordinated development of the vocational education digital governance ecosystem and the digital economy. In the pilot exploration stage, through the joint selection of school - enterprise cooperation units with good digital foundations by the government and industry associations, innovative practices such as the construction of meta - universe training scenarios, the development of AI intelligent evaluation systems, and the construction of digital twin industry - education integration platforms are carried out. In the achievement transformation stage, relying on the vocational education digital innovation achievement evaluation mechanism, scientific methods such as the Delphi method are used to evaluate the effectiveness and universality of the project, transform mature experience into industry standards and norms, and realize the promotion of achievements through the construction of case libraries, special training, and digital

resource platforms. In the dynamic optimization stage, a monitoring index system covering dimensions such as technology adaptability and industrial demand response is constructed. Based on the dynamic evaluation results of the ecosystem, policy standards and resource allocation plans are revised regularly, and the continuous evolution of the ecosystem is promoted through annual academic seminars to ensure that the digital governance ecosystem maintains dynamic adaptation to industrial changes.

4.5 Governance Implementation Path: A Three - dimensional Driven Implementation Framework

Based on the theoretical framework of "policy incentive - technology drive - subject linkage", a three - dimensional collaborative governance system of government, enterprises, and colleges is constructed. At the institutional level, the phased construction goals are clarified through the "Guiding Opinions on the Construction of the Vocational Education Digital Governance Ecosystem", a three - level (ministry - province - college) collaborative mechanism is established, and a third-party evaluation system is introduced to carry out dynamic monitoring. In the dimension of industry - education integration, a virtual simulation training platform is jointly built relying on enterprise data resources, a "dual tutor system" teaching model is implemented, and a talent training quality feedback mechanism is established. In terms of the college implementation path, a data center is built to realize the digital integration of teaching resources, special training on teachers' digital literacy is carried out, a diversified teaching quality evaluation system including digital skill evaluation indicators is constructed, and finally a digital governance ecosystem with multi - subject collaboration and efficient allocation of elements and resources is formed.

5 INNOVATIVE VALUE AND APPLICATION VALUE OF THE DIGITAL GOVERNANCE ECOSYSTEM MODEL

5.1 Innovative Value

This study breaks through the limitations of the "technology - oriented" research paradigm in the traditional digital transformation of vocational education. Based on the cross - perspective of ecosystem theory and digital governance theory, it constructs a tripartite collaborative analysis framework of "subject - technology - environment". By deconstructing the action mechanism and functional boundaries of each element, it innovatively proposes a theoretical construction model of the vocational education digital governance ecosystem, filling the research gap in related fields. At the practical level, the study constructs a pyramid - shaped hierarchical governance structure. Relying on four operating mechanisms (collaborative governance, data sharing, incentive and constraint, and dynamic evolution), it effectively solves practical problems such as weak government leadership, unbalanced school - enterprise collaboration, and slow system iteration under the traditional governance model. Among them, the application of blockchain technology breaks the trust barrier of cross - subject data sharing, and the innovative design of the dynamic evolution mechanism endows the system with adaptive capabilities to adapt to technological innovation and industrial upgrading.

5.2 Application Value

In the process of solving the practical problems of transformation and promoting the implementation of relevant work, it is necessary to solve the key pain points in a targeted manner. In terms of technology integration, relying on the unified standards of the basic support layer, scattered digital resources are integrated to realize "one data center, multi - end reuse". In terms of deepening industry - education integration, enterprises are promoted to participate in depth with the help of collaboration and data sharing mechanisms. When improving digital literacy, the digital teaching ability of teachers and the high - level digital skills of students are significantly enhanced through training and incentive mechanisms. At the same time, it is necessary to provide a replicable practical path for the implementation of the transformation. The model adopts the path of "policy incentive - technology drive - subject linkage", which has strong operability and replicability. Provincial governments can use this to build regional data centers, enterprises can share data relying on the alliance chain, and colleges can promote teaching reform. In addition, the model also takes supporting industrial development and helping the cultivation of digital economy talents as its goals. Through the interconnection of industry - education data and the implementation of virtual training, it accurately meets industrial needs. Colleges can adjust courses according to the real - time needs of enterprises, cultivate compound talents, and effectively alleviate the industrial skill gap.

6 CONCLUSION AND OUTLOOK

This study addresses the governance challenges in the digital transformation of vocational education and constructs a pyramid - shaped digital governance ecosystem model consisting of basic support, core collaboration, and goal achievement. The research shows that the current digitalization of vocational education has shortcomings in technology application, subject collaboration, and governance mechanisms. However, this model realizes the innovation of the governance paradigm by integrating subject, technology, and environment elements and four operating mechanisms, and has both theoretical and practical value. Future research can expand the pilot scope of the model, verify its adaptability in different scenarios and optimize it; explore the integrated application of cutting - edge technologies such as the meta - universe and generative AI with the model; strengthen the empowerment mechanism for disadvantaged

subjects, such as improving incentive policies and support measures; improve data security standards in accordance with relevant laws, and use technologies such as privacy computing to improve the efficiency of data circulation, so as to promote the optimization of the digital governance ecosystem.

COMPETING INTERESTS

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