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Exploration on the Application Mode of Digital Textbooks in Higher Vocational Colleges

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Abstract

In the wave of digital transformation in vocational education, digital textbooks have become a key carrier for the cultivation of skilled talents. In view of the current dilemma of the disordered development process of higher vocational teaching materials and the insufficient depth of integration between production and education, this paper takes the digital teaching material "Application and Maintenance of Intelligent Storage Equipment" as an example to explore the scenario and scenario application mode. By reconstructing the connotation characteristics and development process of digital textbooks, a practical path covering "triple helix coordination, four-stage closed-loop operation, continuous data driving, and three-level quality monitoring" is formed, which provides a reference framework for the systematic construction and teaching mode innovation of digital textbooks in higher vocational colleges.

Keywords

Digital Textbooks, Vocational Education, Application Mode, Intelligent Storage

1. Introduction

With the rapid development of information technology, digital teaching materials have become an important force in education reform, and their construction has risen to a national strategy (Xu et al., 2025). Since 2018, the Ministry of Education has issued documents to promote the R & D pilot; by 2021, it was included in the "14th Five-Year" vocational education national planning textbook declaration and established a juxtaposition with paper-based textbooks. By 2022, the implementation of the strategic action of education digitization and the clear requirements of the report of the 20th National Congress of the Communist Party of China on strengthening the construction of textbooks have improved the policy

system, providing a core driver for digital transformation (Xi, 2022). As a base for training technical and skilled talents, the construction of digital textbooks in higher vocational colleges is of great significance for improving the quality of teaching. However, it still faces difficulties such as a disordered development process, a disconnection between technology and teaching, and a lack of effect evaluation (Yu & Zhang, 2024; Wang et al., 2024). In view of the above problems, based on summarizing the connotation and development principles of digital teaching materials, this paper explores and constructs the scenario and scenario application mode, and carries out reform practice based on the digital teaching materials of "intelligent storage equipment application and maintenance." Through the verification and revision mode in the construction, a set of reference framework for the design and application of digital teaching materials in higher vocational colleges is finally formed.

To clarify the research boundary and theoretical connotation, short operational definitions of the core constructs in this study are given first, and the differentiation between the core research object and similar educational resource forms is further specified, with all definitions oriented to the practical context of higher vocational education talent training and production-education integration. Digital textbooks are the core carrier of native digital teaching in higher vocational education, which integrates information technology and vocational education logic and supports dynamic iteration. Scene-based application is an application paradigm that reconstructs the content of digital textbooks around the real production scenarios of professional positions. Situational application is a digital textbook application path that relies on digital technology to build immersive career scenarios and realizes skill internalization through task-driven learning.

2. Analysis of the Current Situation of Digital Textbook Construction in Higher Vocational Colleges

2.1. Research Status of Digital Textbook Construction

In the global context of the digital transformation of education, digital textbooks have gone beyond simple media changes and become the core driving force to reshape the ecology of vocational education. Since China issued relevant management measures in 2018, traction at the policy level has been significantly enhanced. In particular, the academic status of digital textbooks and paper textbooks has been established in the "14th Five-Year Plan," which marks the completion of the transition from supplementary teaching to the core carrier. However, considering the current situation of domestic research, the field of vocational education is still facing the embarrassment of a lack of unified technical specifications. At present, most of them are in the state of referring to the standards of primary and secondary schools or local pilots and lack an audit mechanism covering the whole country and bearing the characteristics of vocational education (Chen & Guo, 2025). In contrast, the international academic community's exploration of quality evaluation is more systematic, such as the content, teaching, and evaluation trinity

model constructed by South Korea, the strict requirements of data privacy and accessibility in the United States, and the multi-dimensional evaluation framework of educational and technical integration in Germany, all of which provide an important theoretical mirror and reference path for the standardization construction of digital textbooks for vocational education in China (Cheng, 2025).

From the perspective of technology embedding and application paradigm, domestic research is shifting from one-way publishing to "school-enterprise ambidexterity" co-creation, and promoting the evolution of textbooks to native and interactive through intelligent tools (Lin, 2025). Especially in logistics majors, the application of VR simulation, three-dimensional animation, and other technologies has effectively solved the bottleneck of complex skill visualization, and has begun to try to use knowledge maps to connect the post-ability system. Internationally, Singapore's "e-schoolbag" program, Japan's collaborative teaching model, and the AI intelligent learning companion system widely used in European and American countries all reflect the in-depth exploration of technology-enabled personalized learning (Li, 2025). Although current domestic vocational education mostly adopts the mixed form of "paper-number integration" or "loose-leaf teaching materials and online platforms" to support the integration of theory and practice teaching, the in-depth evaluation mechanism of post docking and the construction of ubiquitous learning ecology are still in the critical period of transition from experience exploration to data-driven transformation. It is urgent to solve the practical dilemma of insufficient depth of integration of production and education and lagging content updates through path innovation of typical cases, such as "application and maintenance of intelligent storage equipment" (Xu, 2024).

2.2. The Realistic Dilemma of Digital Textbook Construction in Higher Vocational Colleges

Although the policy environment has been continuously optimized, the connotation definition of digital textbooks in higher vocational colleges is still vague. The academic community has not yet reached a deep consensus on its functional orientation as a trinity of knowledge carrier, activity scaffold, and ability platform. This superficial cognition directly leads to the imbalance of the focus of construction. Some developers overindulge in the gorgeous dazzling of technology presentation, but weaken the internal integration of teaching materials, professional ability, and production process, making digital teaching materials often empty of the name of interaction and helpless. At the same time, the weak theoretical support further restricts the evolution of development logic. Due to the lack of systematic methodological guidance, it is difficult to accurately transform dynamic industrial standards into modular learning content. How to organically crush and reshape the elements of "Position-Course-Competition-Certificate" in the digital space is still a technical pain point that plagues colleges and enterprises. This experience-driven, rather than theory-led development model not only weakens the scientific nature of the content, but also makes the digital textbooks show obvious lag in dealing with industrial technology iteration.

From the perspective of the ecological construction of practice, the promotion and application of digital textbooks are facing the dual dilemma of subject adaptability and resource quality. Due to the habitual path dependence or technological application bottleneck of some teachers and students in the integration of digital resources, as well as the fact that a large number of textbooks on the market are essentially digital versions of paper content, lacking in-depth interaction design and an intelligent feedback mechanism, there is a serious phenomenon of "two skins" between technology and teaching in classroom instruction. In addition, the fragmentation of the support system is also a realistic challenge that cannot be ignored. Especially in the context of the absence of specialized evaluation tools suitable for vocational education and the imperfect dynamic update mechanism and copyright protection mechanism, the potential of digital textbooks is constrained within a relatively closed system. The lack of systematic guarantees makes it difficult for digital textbooks to truly penetrate into the core link of teaching reform, which restricts the significant leap from the digital transformation of vocational education to connotative development.

3. Practical Reform Content of Digital Textbook Application Mode in Higher Vocational Colleges

In view of the shortcomings in the construction of digital teaching materials in higher vocational colleges, this paper is based on the closed-loop research framework of "theoretical research-development practice-application verification-model optimization." On the basis of summarizing the concept and connotation of digital teaching materials, the principles of design, development, and application, methods, and strategies, this paper designs and develops the scene and situational application mode of digital teaching materials, and relies on the digital teaching materials of "intelligent storage equipment application and maintenance" to carry out practical reform, verify and revise the mode in the construction process, and finally form a relatively complete design and application mode of digital teaching materials in vocational colleges. In order to provide typical cases and standardized references for the construction of digital textbooks for vocational education in China, the overall research framework is shown in Figure 1.

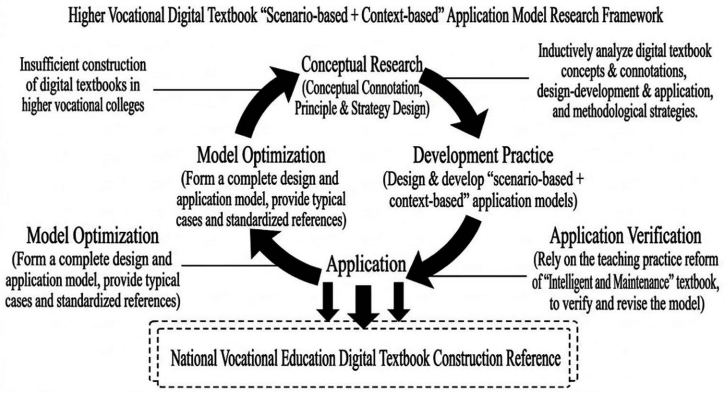

Figure 1. Overall research framework.

3.1. Systematic Reconstruction of the Connotative Characteristics of Digital Textbooks in Higher Vocational Colleges

The construction of digital teaching materials in higher vocational colleges is experiencing a key leap from policy-driven to connotation self-growth. In theoretical logic, digital teaching materials have evolved from the electronic form of paper books to a new knowledge field integrating information technology and vocational education logic. By breaking the linear and closed transmission paradigm, a dynamic ecosystem supporting ubiquitous learning and instant feedback is constructed, and the dual positioning of knowledge carrier and enabling platform is established. The dimension of content construction requires that textbooks must maintain a high degree of resonance with industrial upgrading and technological iteration, and rely on the agile update mechanism to transform new industry norms, new processes, and real cases into teaching resources in real time, so as to promote knowledge presentation from abstract symbols to concrete scenes. By constructing the content architecture of the deep integration of "Position-Course-Competition-Certificate," using high simulation models and interactive tasks, students can realize the deep internalization of skills in the simulated environment. The technology-enabling level should focus on the enhancement of sensory experience and the visual presentation of skill logic, and provide the underlying support for precise teaching intervention through intelligent interaction and learning data tracking. The ultimate value of technology lies in returning to the essence of vocational education and providing a solid fulcrum for the implementation of scenario-based and scenario-based teaching models.

3.2. Reconstruction of the Digital Textbook Development Process System Based on the Integration of Production and Education

In order to realize the substantive transformation of higher vocational digital textbooks from resource transplantation to original co-creation, it is necessary to reshape the development paradigm and build a collaborative architecture with deep coupling of the teaching team, enterprise technical backbone, and professional platform. Under this interest community mechanism, school-enterprise cooperation runs through the whole process of demand co-presentation, framework co-construction, and resource co-creation. Enterprises provide production technical specifications and real cases to ensure the professional depth and industrial fit of teaching materials; teachers in colleges and universities give full play to the advantages of pedagogy and transform industrial language into modular learning units; the technical team uses tools such as low-code platforms to lower the development threshold.

The three-party linkage has solved the practical problems of uneven school-enterprise cooperation and the disconnection between technology and teaching from the source. The specific implementation dimension has constructed a five-order closed-loop process including demand anchoring, content reconstruction, technology embedding, dual quality inspection, and cloud iteration (**Figure 2**). The process is guided by the demand for industrial talents, integrates the stand-

ards and certificate points of vocational education competition, and builds a modular knowledge map around the logic of real production tasks by breaking down the barriers of subject chapters. The technical link emphasizes lightweight and high interactivity, and uses virtual reality technology to develop training scenarios with real-time feedback. Quality control introduces a two-way cross-audit mechanism between schools and enterprises. Teachers are responsible for the coherence of teaching logic, engineers verify the accuracy of technical parameters, and jointly complete the acceptance of results.

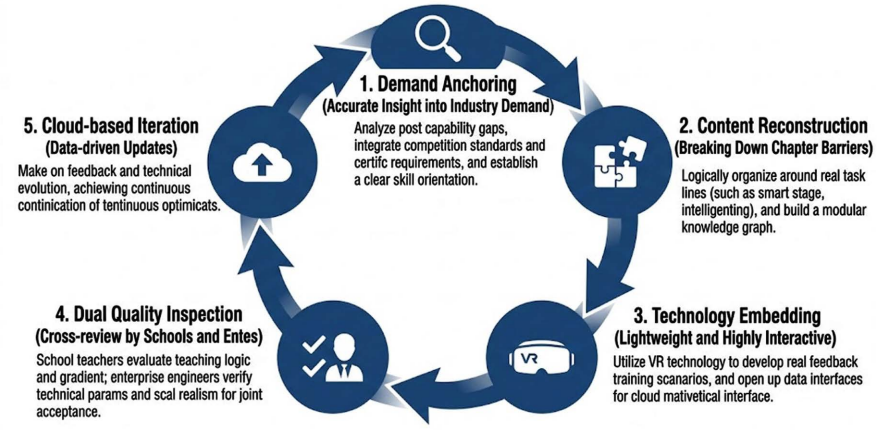

Figure 2. Fifth-order closed-loop process.

In order to ensure the continuous vitality of digital textbooks, it is particularly critical to establish a long-term mechanism for data-driven updates and a closed-loop system guarantee. By embedding a real-time monitoring module in the teaching application, the system can dynamically diagnose the weak links in teaching and accurately push resources according to the learning behavior data. At the same time, relying on the school-enterprise joint meeting mechanism, it ensures that the content of the textbook can be updated synchronously with the evolution of industry technology. At the management level, a three-level security system composed of the executive layer, the collaborative layer, and the expert layer is implemented, which undertakes the responsibilities of standard verification, teaching review, and strategic review, respectively, and forms an educational ecology that can respond quickly to industrial changes and support the adaptive improvement of talent training.

3.3. The Reform Practice of Digital Textbook Scenarios and Situational Application Modes in Higher Vocational Colleges

This paper takes the scene as the core carrier, adopts situational teaching as the implementation path, and relies on the digital teaching material of "intelligent storage equipment application and maintenance" to create a digital learning field integrating virtual and real elements. By integrating the virtual simulation platform, a training module covering fault diagnosis, virtual operation, and instant feedback is developed, which fully simulates the production process of intelligent

storage. The supporting three-dimensional resource library provides students with an interactive device model that enables them to immerse themselves in real work situations. The teaching process emphasizes inquiry and experiential learning. Through the closed-loop design of "cognition-practice," the students' awareness of autonomous learning and professional quality is significantly enhanced.

To objectively verify the effectiveness of the scenario-based and situational application model, a quasi-experimental study was conducted over one semester in the railway logistics management program at Guangzhou Railway Polytechnic. Two parallel classes with comparable academic backgrounds were selected as the experimental group (N = 62, using the new digital textbook application mode) and the control group (N = 60, using the traditional teaching mode). The assignment of classes was based on natural class groupings, and baseline equivalence was established by comparing students' prior academic performance. Analysis of entrance examination scores and final grades from the prerequisite course "Logistics Information Technology" revealed no statistically significant differences between the two groups (experimental group: mean = 82.3, SD = 5.6; control group: mean = 81.9, SD = 5.8; independent samples t-test, $p = 0.72 > 0.05$), confirming that the groups were equivalent at baseline in terms of academic ability.

To control for teacher variability, both classes were instructed by the same faculty member with five years of teaching experience in the specialized field. All instructional conditions were held constant between the two groups except for the textbook mode: both groups followed the same curriculum content, had identical class hours (4 hours per week for 16 weeks), used the same laboratory equipment, and completed the same final assessment consisting of both theoretical and practical components. The experimental group engaged with the digital textbook's virtual simulation platform, which included training modules covering fault diagnosis, virtual operation, and instant feedback within an intelligent warehousing context. The control group used traditional paper-based textbooks and lecture-based instruction without digital simulation components.

Throughout the semester, learning behavior data were automatically collected through the digital textbook platform for the experimental group. Final assessment results showed that the experimental group achieved a mean score of 89.5, with 45.1% of students attaining excellence (scores above 90), compared to significantly lower performance in the control group. Additionally, the experimental group demonstrated an average weekly active learning time of 4.5 hours, representing a 38.2% increase over the control group. Blind evaluations conducted by enterprise supervisors further indicated that students in the experimental group exhibited clearer problem-solving approaches and more professional performance when addressing real-world production scenarios. These findings provide robust evidence that the scenario-based digital textbook application mode effectively addresses the challenges of monotonous theoretical learning and insufficient practical skill development, offering a replicable reference model for similar vocational courses.

Several limitations should be considered when interpreting the findings. First, although the same instructor taught both groups to control for teacher effects, unmeasured differences in instructional delivery cannot be entirely ruled out. Second, the novelty effect may have inflated the experimental group's engagement, as first-time exposure to digital textbooks could temporarily boost motivation. Third, the experimental group's higher average weekly active time (4.5 hours versus 3.2 hours in the control group) suggests potential differences in time-on-task, which may partially explain the observed learning gains. Fourth, prior platform familiarity was not assessed at baseline, introducing a possible confounding variable. Regarding causal inference, the equivalence in prior academic performance and the controlled conditions (same teacher, content, and assessment) support a causal interpretation of the final score differences. However, the engagement metrics should be viewed as associational findings, as they may reflect both the intervention effect and students' voluntary effort. Future research should employ randomized designs and measure digital literacy and time-on-task more precisely.

3.4. Model Description: Operational Framework of the Digital Textbook Application Mode

The proposed application mode for digital textbooks in higher vocational colleges is operationalized through an integrated framework that specifies the necessary inputs, procedural steps, and expected outputs, thereby enabling replication and adaptation in diverse educational contexts. The model synthesizes four core mechanisms—"triple helix collaboration, four-stage closed-loop operation, continuous data-driven adaptation, and three-level quality monitoring"—into a coherent process that transforms industrial and educational resources into dynamic teaching and learning solutions.

The inputs to the model comprise three interrelated categories: human resources, content sources, and technological infrastructure. Human resources include a cross-functional team of vocational educators, enterprise technical experts, and platform developers who collectively bring pedagogical expertise, industry insight, and technical capability. Content sources consist of authentic industrial standards, real-world production cases, and vocational competency frameworks derived from job analysis and integration of the "Position-Course-Competition-Certificate" elements. Technological infrastructure encompasses low-code development platforms, virtual reality and simulation tools, cloud-based learning management systems, and application programming interfaces (APIs) that enable real-time connectivity with industrial equipment and data streams.

The process of the model unfolds through the synergistic operation of the four core mechanisms. Triple helix collaboration ensures that the development of digital textbooks is co-led by educators, industry practitioners, and technologists, with each party contributing to demand articulation, content co-construction, and technical validation. This collaboration is operationalized within a four-stage closed-loop process: design, development, application, and optimization. In the design stage, industrial job tasks are deconstructed and mapped onto a modular

knowledge graph, and virtual simulation scripts are co-created. The development stage transforms these designs into interactive digital resources, subject to a dual-review mechanism involving both pedagogical and technical scrutiny. During the application stage, the digital textbook is deployed in authentic teaching settings, where pre-class, in-class, and post-class activities are supported by the platform, and learner interaction data is continuously collected. The optimization stage leverages these data to drive iterative improvements: the system diagnoses learning difficulties, adaptively recommends resources, and, through school-enterprise information sharing, incorporates updates from industrial technology evolution into the textbook content in near real time. Throughout this cycle, a three-level quality monitoring mechanism operates at the execution, collaborative, and strategic layers, ensuring that milestone achievements, cross-validation of content, and alignment with broader educational policies are systematically maintained.

The outputs of the model are multifaceted and extend beyond the digital textbook itself. Primary outputs include a contextually relevant and dynamically updatable digital textbook that mirrors real-world industrial processes and supports competency-based learning. Additionally, the model yields a reusable and scalable development and application framework that can be adapted to other vocational disciplines and institutions. In terms of learning outcomes, empirical evidence from the case of "Application and Maintenance of Intelligent Storage Equipment" demonstrates that the model enhances student engagement, improves skill acquisition, and fosters better preparation for workplace demands. Finally, the embedded quality assurance mechanisms produce systematic feedback that informs the continuous improvement of both the textbook content and the teaching process, thereby closing the loop between educational practice and industrial evolution.

By articulating these inputs, processes, and outputs, the model provides a clear and actionable blueprint for higher vocational colleges seeking to implement or refine their own digital textbook initiatives, moving from high-level principles to reproducible practice.

4. The Practical Path of the Application Mode of Digital Textbooks in Higher Vocational Colleges

In order to implement the above-mentioned scene-based and situational digital textbook application mode, it is necessary to build a systematic, operable, and sustainable practice path. The path takes "triple helix coordination, four-stage closed-loop operation, continuous data driving, and three-level quality monitoring" as the core mechanism, aiming to open up the whole chain from textbook development to teaching application, and effectively solve practical problems such as the disconnection between traditional textbooks and professional practice and the lag of content update.

4.1. Build a Triple Helix Collaborative School-Enterprise Collaborative Development Framework

In order to break the bottleneck of the single development subject of traditional

teaching materials and the disconnection with the industry, higher vocational colleges should build a triple helix collaborative architecture deeply coupled by the teaching team, enterprise technology backbone, and professional technology platform. In this architecture, the three parties form an interactive closed loop through complementary responsibilities.

The school teaching team is responsible for transforming the typical post tasks in the field of intelligent warehousing into modular learning projects that conform to the cognitive law. Enterprise experts provide job standards and real production cases, and conduct technical audits on key nodes such as VR simulation parameters to ensure that the content of teaching materials is highly compatible with industry norms. The technical team uses the low-code platform and the game engine to provide the underlying support to achieve a high degree of simulation of the training environment. By connecting the industrial platform API, the digital textbook can call the equipment operation data in real time, create a learning situation that is immediately linked to the production site, and finally realize the deep integration of teaching implementation and industrial practice.

4.2. Develop a Four-Stage Closed-Loop Propulsion Process

The construction of digital textbooks is a systematic project, and its logical starting point is to realize the educational reconstruction of the curriculum framework through in-depth industrial research. In the design stage, leading enterprises such as Guangzhou Metro and Jingdong Logistics are coordinated. Through the systematic deconstruction of the core competence of the post, the dual-track parallel mode of knowledge map and virtual simulation script is adopted to transform the complex equipment principle and fault logic into a structured prototype that conforms to cognitive law and is closely connected with the actual industry.

After entering the development stage, the quality of teaching materials is guaranteed through the dual audit mechanism of college teachers and enterprise experts, the knowledge map is transformed into a step-by-step learning task, and the 3D interactive model and virtual simulation platform are integrated to complete the resource transformation. The application and optimization stage focuses on the reshaping of the teaching paradigm. The implementation system of pre-class cognition, in-class training, and after-class tracking is implemented in the pilot class, and the cloud platform is used to dynamically collect data to drive the precise intervention of teaching. The final optimization link relies on multi-dimensional learning situation data to adjust the training gradient, and combines the real-time revision content of industry technology evolution to build a dynamic textbook ecology that is agile in response to industrial changes.

4.3. Establish a Data-Driven Technical Support System

In order to ensure that digital teaching materials can continuously enhance teaching efficiency, this paper constructs a set of data-centered technical systems covering the whole cycle of diagnosis, update, and support, aiming to provide solid

intelligent underlying support for digital teaching in vocational education. The logical focus of this system is to establish a full-cycle learning behavior intelligent diagnosis engine. Relying on the digital textbook platform, the system can dynamically collect students' operation trajectories, task completion, and knowledge internalization data in virtual training, so as to accurately identify group skill shortcomings and individual learning disabilities.

This kind of accurate insight based on learning data promotes the transformation of teaching intervention from traditional experience-oriented to data-driven: the system can automatically trigger an adaptive intervention mechanism according to the diagnostic conclusion, push the optimization scheme to the teacher side, and recommend to the student side. Stepwise learning resources that match their current abilities effectively implement individualized teaching in large-scale teaching scenarios. In view of the dilemma that textbooks lag behind industrial evolution, a knowledge preservation mechanism for industry-education coordination is established by opening up the information sharing channel between schools and enterprises. With deep linkage with leading enterprises such as rail transit and intelligent warehousing, the textbook team can capture industry standard updates and process changes in real time. Relying on the agile iterative process in the cloud, the new technical specifications can be quickly integrated online through educational reconstruction, ensuring the synchronous evolution of the textbook knowledge system and industry needs, and maintaining the continuous adaptability between talent training and job requirements.

4.4. Implement a Three-Level Closed-Loop Quality Monitoring Mechanism

In order to ensure the steady progress of digital textbook development on the preset quality track, it is necessary to build a closed-loop monitoring system that runs through the three layers of execution, coordination, and strategy, and realizes the system optimization of textbook construction in feedback through full-dimensional quality assurance. The execution layer introduces the fine management of the whole life cycle, and realizes the transformation from static evaluation to dynamic process control by setting milestone nodes and monthly progress tracking. The project leader continuously evaluates the fit between the technical path and the teaching objectives, and uses agile management methods to adjust the development path in time to ensure that the quality of resource development is always closely related to the core objectives in the whole process.

The collaborative dimension constructs a dual cross-review model with the participation of college teachers and enterprise experts, and solves the problem of disconnection between teaching resources and industry through quarterly structured review. The teaching team is responsible for examining the degree of matching between the logic of the knowledge system and learning activities. Enterprise experts focus on verifying the authenticity of technical scenarios and the accuracy of process parameters. Through two-way feedback and improvement paths, the

deep integration of educational laws and technical specifications is realized. At the strategic level, a high-level evaluation group composed of teaching and scientific research institutions, industry think tanks, and publishing experts is set up to carry out periodic reviews and final acceptance, so as to enhance the strategic position of textbook construction. The evaluation focuses on the adaptability of textbooks and digital policies, the support efficiency for industrial development, and the generalization of models, and realizes the systematic upgrading from simple technology development to educational innovation and ecological construction with the help of a forward-looking vision.

5. Conclusion

The construction and application of digital textbooks have become the core engine to promote the digital transformation of vocational education and realize the deep reform of the teaching mode. This paper takes the digital textbook "Application and Maintenance of Intelligent Warehousing Equipment" as the starting point. Through in-depth theoretical construction and empirical exploration, it systematically puts forward the application paradigm with scenario and scenario as the main line, and on this basis, forms a practical path covering "triple helix coordination, four-stage closed-loop operation, continuous data driving, and three-level quality monitoring." This path not only effectively promotes the organic integration of production and education resources and the dynamic update of teaching content at the mechanism level, but also verifies the significant role of digital textbooks in improving students' learning engagement and enhancing the effectiveness of skills training in practical teaching applications. It provides an operable and iterative implementation framework for higher vocational colleges to promote the digitization of teaching materials and the intelligentization of teaching.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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