Theory and Practice of Fully Digital Textbook Development for Vocational Education

Zhaoxia Zhang[1]

[1] *Guangzhou Civil Aviation College, Guangzhou, Guangdong 510403, China*
[1]*Corresponding author. Email: zhangchaoxia@gcac.edu.cn*

ABSTRACT

Fully digital textbooks for vocational education is the intelligent learning ecosystem that integrates cutting-edge technologies such as artificial intelligence VR/AR, big data and blockchain, with characteristics of integration, interactivity, and personalization. Its development is guided by constructivism and cognitive load theory, following principles such as professionalism, timeliness, and multimedia integration. Through a systematic design strategy, it achieves a closed loop of "theory-practice-evaluation". Its key technologies include AI-driven personalized learning recommendations, immersive training scenarios built with VR/AR, dynamic optimization of content supported by big data, and copyright security guaranteed by blockchain. The development process covers aspects such as requirement analysis, framework design, and content writing, emphasizing school-enterprise collaboration and an integrated architecture of "cloud-edge-end". In the future, digital textbooks will develop towards deep scene based, highly intelligent, and ecological collaboration, but attention should also be paid to the balance between technological applications and the essence of education. The innovative development in this field is of great significance for cultivating high-quality technical and skilled talents, and provides a Chinese solution for global digital education.

Keywords: Vocational education, Digital textbooks, Fully digital textbooks.

1. INTRODUCTION: OVERVIEW OF DIGITAL TEXTBOOKS FOR VOCATIONAL EDUCATION

This article will discuss the definition of digital textbooks, the characteristics of digital textbooks, and the development of fully digital textbooks for vocational education from three aspects:

1.1 Definition of Digital Textbooks

Digital textbooks refer to modern network multimedia dynamic textbooks that fully utilize the advantages of digital technology to support textbook reform, integrate textbooks, media, resources, activities, practical training, and the internet based on digital technology, can carry digital, intelligent, and smart teaching activities, fully meet the needs of teaching assistants, students, training assistants, evaluation assistants, research assistants, etc., and fully present and apply them in the digital environment. [1] The architecture diagram of the integrated digital teaching platform/publishing platform equipped with digital textbooks is shown in "Figure 1".
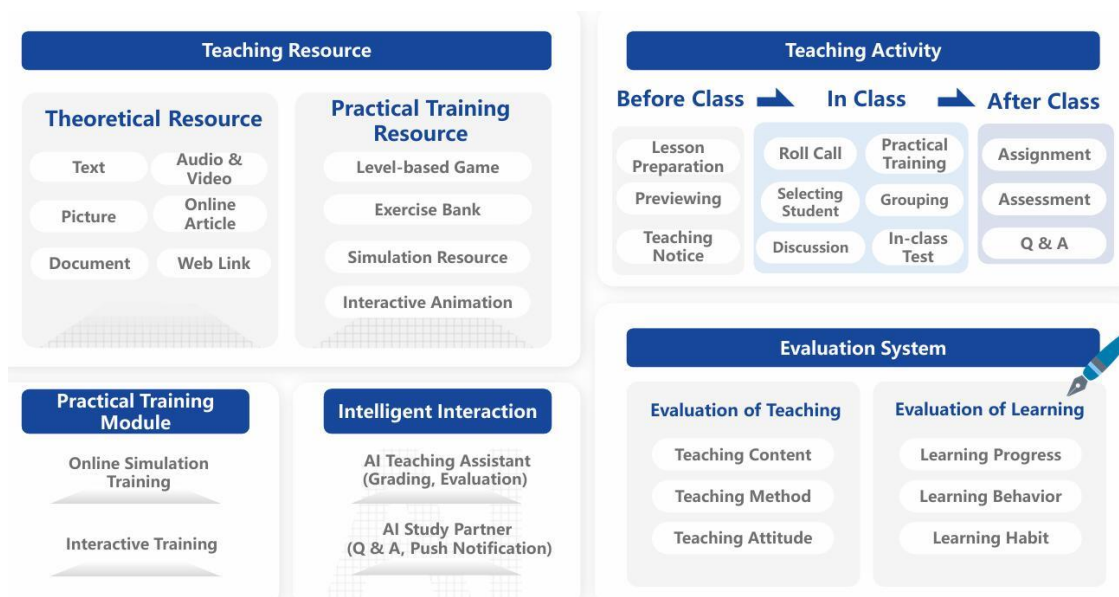
Figure 1 Architecture diagram of integrated digital teaching platform/publishing platform.

1.2 Characteristics of Digital Textbooks

The construction of digital teaching materials requires "taking talent cultivation and moral cultivation as the target requirements, taking curriculum standards as the basis, and considering the characteristics of learners", "using the Internet, digital media, big data and other technical means to integrate the content of paper teaching materials, digital resources, subject tools, and application data" [2], which reflects the concept of deep integration of education content, resources and modern information technology against the background of "Internet+" and "smart education+", and has the characteristics of integration, rich media, interactivity, intelligence, and personalization. (See "Figure 2" for details) [1]
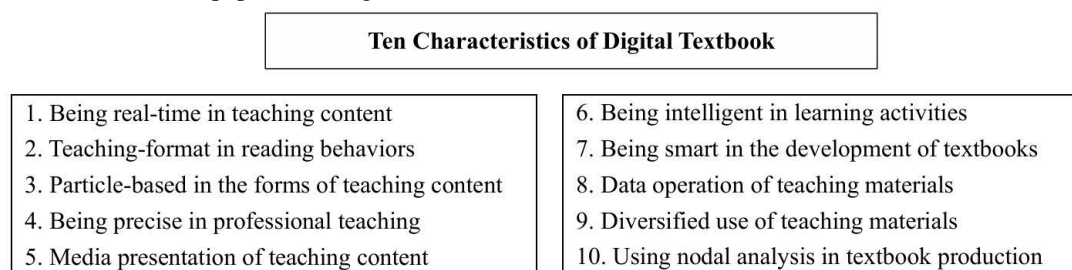

Figure 2 The ten characteristics of digital textbooks.

1.3 The Development of Fully Digital Textbooks for Vocational Education

From the first batch of selected textbooks for the "14th Five-Year Plan" for vocational education announced by the Ministry of Education in 2023 and the second batch of recommended textbooks for the "14th Five-Year Plan" for vocational education announced by various regions in 2025, it can be seen that there is a growing trend in the selection of digital textbooks, but most of them are presented in a mixed format of "digital+paper" mainly in paper form (see "Figure 3"). In the future, it is necessary to strengthen top-level design, improve technical standards, continuously consolidate the digital foundation characterized by digital new infrastructure, and promote the popularization and application of truly fully digital interactive teaching materials.
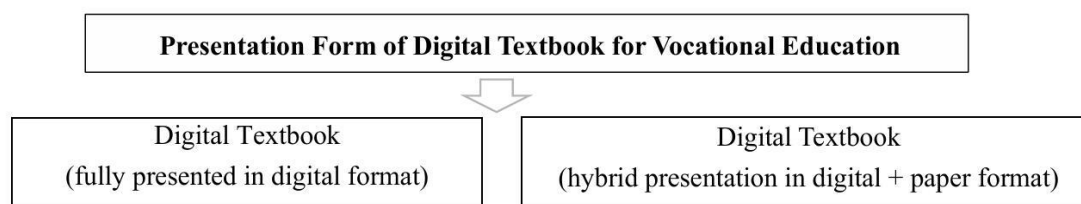
Presentation Form of Digital Textbook for Vocational Education

Digital Textbook (fully presented in digital format)	Digital Textbook (hybrid presentation in digital + paper format)

Figure 3 Presentation forms of digital textbooks for vocational education.

2. THEORETICAL BASIS OF FULLY DIGITAL TEXTBOOK DEVELOPMENT FOR VOCATIONAL EDUCATION

The development and construction of fully digital textbooks for vocational education mainly involves two aspects: learning theory and teaching design theory:

2.1 Learning Theory

Constructivist learning theory emphasizes that learning is the process of learners actively constructing knowledge in a context with the help of others and resources. This theory has important guiding significance for the development of fully digitized vocational education textbooks. Taking the flight attendant profession as an example, digital textbooks can use virtual reality (VR) technology to construct realistic cabin environments, allowing students to immerse themselves in the working environment of flight attendants. In the virtual cabin, students can simulate typical work tasks such as safety demonstrations, emergency equipment operations, and cabin services. Through interaction with virtual passengers and emergency response, they can actively construct professional knowledge of service processes and emergency response. This contextualized digital textbook not only enhances learning immersion, but also helps students deepen their understanding of professional knowledge and cultivate professional abilities through practical operations in a simulated environment.

The cognitive load theory suggests that reasonable control of cognitive load can effectively improve learning efficiency. In the design of digital textbooks for civil aviation security check English, a modular and progressive presentation approach should be adopted: first teach basic security check terminology (such as metal detector, X-ray machine), and then transition to a complete dialogue scenario (such as passengers inquiring about prohibited items). By highlighting key sentence patterns (such as "Please remove your... before passing through the metal detector. ") and visually indicating key vocabulary (such as prohibited items), teachers can help students focus on the core content. Simultaneously, teachers can also set up layered exercises, gradually deepening from word recognition to situational dialogue, to avoid information overload and ensure that students can effectively absorb professional knowledge at every stage.

2.2 Teaching Design Theory

The theory of instructional design is mainly applied in the development of fully digital textbooks for vocational education, focusing on content organization and instructional activity design. Taking the development of digital textbooks for aircraft maintenance as an example, in terms of content organization, a modular knowledge system should be constructed according to the typical workflow of aircraft maintenance, such as pre-flight inspection, fault diagnosis, component replacement, system testing, etc. Each module integrates relevant theories (such as aircraft construction principles) with virtual reality (such as engine disassembly and assembly VR simulation), forming a closed-loop learning path of "theory-virtual training-evaluation feedback". Through digital means such as 3D interactive maintenance manuals and AR assisted troubleshooting, the maintenance standard procedures (such as AMM manual operation steps) are transformed into immersive learning experiences, helping students systematically master the core skills of aircraft maintenance in simulated real work scenarios.

In terms of instructional activity design, teaching design theory emphasizes on student-centered approach, and designing diverse teaching activities to stimulate students' interest and initiative in learning. In the design of digital teaching materials for aviation service English speaking, multi-level interactive teaching activities can be set up: through AI scenario dialogue simulation (such as passenger check-in, cabin

service, etc.), students can interact with virtual characters in real time to practice professional speaking; In the classroom, teachers can set up a "special situation handling discussion area" (such as flight delay response) to encourage students to share solutions; Teachers can also design team role-playing tasks, simulate the complete service process (from boarding to seeing off passengers) in groups, and cultivate teamwork skills; it is necessary to use speech recognition technology to provide real-time pronunciation correction, and set up 3D game-style graded scenario challenges (from greetings to emergency cabin announcements), gradually improving students' professional language application abilities.

3. PRINCIPLES AND STRATEGIES FOR THE DEVELOPMENT OF FULLY DIGITAL TEXTBOOKS FOR VOCATIONAL EDUCATION

The development of fully digital textbooks for vocational education adheres to the following five principles and four strategies:

3.1 Development Principles

Professionalism is the core principle of the development of fully digital textbooks for vocational education. The content of the textbook should be closely integrated with professional standards or norms and work processes and procedures, using typical or real work projects and tasks as carriers, and incorporating typical production cases, reflecting the integration of theory and practice. In the development of digital textbooks for aviation logistics management, the textbooks should focus on typical business processes of air cargo transportation, and integrate IATA standards and civil aviation regulations around core job tasks such as cargo collection, warehouse management, apron operations, and transportation of dangerous goods. By simulating real work scenarios such as airport cargo terminal operations and route network optimization decisions in 3D, professional skills training such as air waybill filling and ULD assembly are integrated into the learning process. Simultaneously, aviation logistics safety cases, civil aviation professional ethics standards, and other content are integrated to cultivate students' rigorous and meticulous professional qualities, enabling them to establish professional values that meet industry standards while mastering professional skills.

Timeliness is also one of the important principles. In the era of digital education, vocational education must timely reflect the latest developments and technical standards in the industry, and integrate new technologies, processes, and norms in the industry in a timely manner. Taking civil aviation as an example, with the advancement of smart civil aviation construction, digital textbooks must be integrated in real-time with cutting-edge technology standards such as RNP-AR navigation technology, ACARS data link communication, and airport FOD intelligent monitoring. By integrating the updated airworthiness regulations of the Civil Aviation Administration of China and the actual operation of airlines, it will be a necessity to dynamically integrate new technical specifications such as the GADSS global aviation distress system and HUD head up display. By leveraging the advantages of digital teaching platforms, innovative application content such as aircraft health management systems (AHM) and digital twin maintenance can be quickly updated, ensuring that students master the latest technological trends in the industry and cultivate high-quality technical and skilled talents suitable for the development of smart civil aviation.

The nature of media convergence is a prominent feature of digital textbooks and a fundamental principle that should be followed in the development process. In the digital textbooks of civil aviation transportation services, the textbooks should integrate multimedia elements such as 3D animation to demonstrate the principle of aircraft load balancing, VR simulation of check-in counter operation processes, and AR presentation of dangerous goods transportation regulations. Through diversified forms such as real-time flight dynamic data visualization, airport operation delay photography, and cabin service scenario drama videos, the entire process of civil aviation transportation is vividly presented. Simultaneously supporting cross terminal access, students can conduct in-depth simulation training through PC and access professional materials such as electronic flight bags (EFBs) at any time through mobile devices, achieving a seamless connection between "theory-virtual training-mobile learning" and comprehensively improving the quality of civil aviation transportation talent training.

The principle of interactivity emphasizes that digital textbooks should provide rich interactive functions to enable students to actively participate in the learning process.

In the digital textbooks of airport operations, the principle of interactivity is reflected as follows: students can conduct virtual command through the tower control simulation system, receive real-time flight dynamics generated by AI, and make decisions; students participate in the sand table simulation of aircraft position allocation, and the system provides real-time feedback on operational efficiency evaluation; In the special situation handling module, multi-role collaborative exercises can be conducted with virtual crew and ground personnel. The digital textbook also provides functions such as flight delay handling decision tree analysis, interactive annotation of runway intrusion risk points, and a professional discussion area to share operational cases, enabling students to master core professional skills such as A-CDM collaborative decision-making through deep interaction.

The principle of intelligence utilizes artificial intelligence technology to achieve personalized learning and intelligent management of digital textbooks. By analyzing students' learning data, such as learning progress, answer situation, learning time, etc., digital textbooks can understand students' learning habits and knowledge mastery level, and provide personalized learning suggestions and content recommendations for students. When students encounter difficulties in the learning process, the intelligent tutoring system can automatically push relevant knowledge point explanations and practice questions to help students solve problems. Digital textbooks can also automatically adjust the difficulty and pace of learning according to students' learning situation, achieving personalized teaching. Intelligence is also reflected in the intelligent management of textbooks. Teachers can use the digital textbook management platform to real-time understand students' learning situation, conduct teaching evaluation and management, and more accurately complete students' digital portraits, improving teaching efficiency and quality.

3.2 Development Strategies

The development of fully digital textbooks requires a systematic and forward-looking design strategy. In the development process, it is necessary to abandon the linear thinking of traditional paper textbooks and instead build a three-dimensional content system based on multidimensional knowledge graphs. The development team needs to first plan the overall architecture of the digital

textbook, including core knowledge modules, virtual training scenarios, intelligent evaluation systems, and other components, to ensure the organic connection between each element. This development mode emphasizes "one lesson, one model", that is, customized development is carried out according to different courses of different majors to ensure that customized education and individualized teaching are really achieved. At the same time, fully leveraging the advantages of digital technology, dynamic presentation and personalized adaptation of teaching content can be achieved through built-in XR training platform, AI learning assistant, big data analysis system and other functional modules. Teachers can monitor their learning progress in real-time and intelligently push differentiated learning resources through an integrated teaching platform; Students can complete the entire process of learning from knowledge construction to skill mastery in an immersive environment. This development approach not only avoids the common problem of functional fragmentation in the digitalization process of traditional textbooks, but also enables continuous iteration and updating of teaching content through algorithm optimization, ensuring synchronization with industry technological development.

Dual development of schools and enterprises is an important strategy for the development of digital textbooks in vocational education. The characteristics of vocational education determine that its textbook content should be closely integrated with the actual needs of the industry. Therefore, it is crucial to invite industry experts and technical personnel to participate in the development of digital textbooks. The enterprises have professional advantages in the completeness of its capability target structure, the practicality of its production process, and the scientificity of its cases. It can provide new requirements for professional quality in technological transformation and upgrading, corresponding industry and professional standards, mainstream enterprise job norms, excellent industry culture, and other basic materials for work sites. [4] School teachers play a role in ensuring political direction, targeted content, standardized language, and reasonable writing progress. [4] Both sides complement each other's strengths and weaknesses, and jointly create high-quality digital textbooks. Through the dual development of schools and enterprises, it can also promote deep cooperation between schools and enterprises, provide more internship and employment opportunities for students, and

"promote seamless integration between talent cultivation and industry demand". [5]

Building an integrated intelligent education publishing system of "cloud-edge-end" is crucial for developing a fully digitized textbook publishing platform based on digital new infrastructure. The platform should deeply integrate 5G, cloud computing, and artificial intelligence technologies to create a full process digital solution that integrates textbook publishing, online courses, virtual training, and intelligent evaluation, as shown in "Figure 4". [1] On the platform architecture, data interconnection between publishing institutions, vocational colleges, and industry enterprises is achieved through the education private network, and a dynamically updated vocational education knowledge base is constructed; In terms of functional design, the platform supports intelligent matching between textbook content and national level high-quality online courses, achieving automatic association between knowledge points and micro course videos, XR training scenarios. The publishing process adopts blockchain technology to ensure copyright security, while utilizing big data analysis to achieve real-time feedback and dynamic optimization of textbook usage effects. This new publishing model can break the boundary between traditional textbooks and online courses, forming a closed-loop ecosystem of "content production-intelligent push-learning analysis-iterative optimization", and providing infrastructure support for the digital transformation of vocational education.
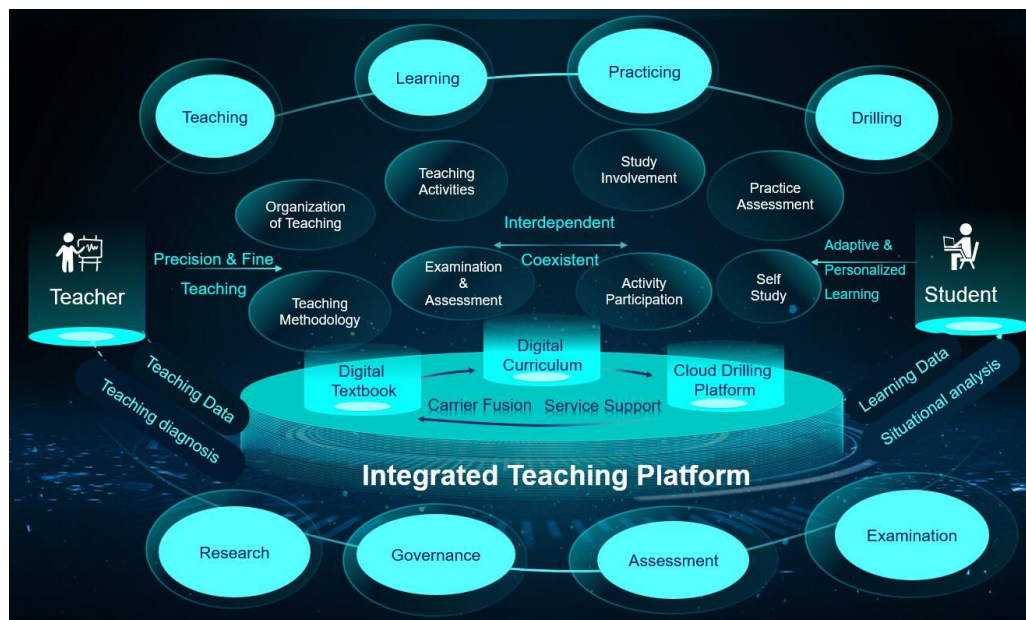

Figure 4 Integrated teaching platform with convergence mode.

Technological innovation and application strategies are key to enhancing the functionality and teaching effectiveness of digital textbooks. Actively introducing advanced digital technologies such as artificial intelligence, blockchain, VR, AR and other immersive technologies to endow digital textbooks with more functions and advantages. Utilizing artificial intelligence technology can help to achieve personalized learning recommendations, intelligent tutoring, and learning assessment; Creating an immersive learning environment for students through technologies such as VR and AR can help to enhance the fun and interactivity of learning; Using blockchain technology can help to safeguard the copyright and data security of digital textbooks. In the digital textbook of drone application technology, a fully realistic flight simulation environment is constructed through VR, allowing students to immerse themselves in practicing operations such as route planning and emergency obstacle avoidance; Using AR technology will help to achieve 3D disassembly teaching of drone components, and scanning the QR code of the textbook, students can view the dynamic working principle of the engine. The intelligent error correction system analyzes student control data in real-time and automatically generates flight attitude optimization suggestions; Based on machine learning, the changes in flight characteristics can be simulated under different

meteorological conditions, thus reflecting the deep integration of artificial intelligence. By continuously innovating and applying new technologies, digital textbooks can better adapt to the teaching needs of the digital age, improve teaching quality, and enhance students' learning outcomes.

4. THE DEVELOPMENT PROCESS AND KEY TECHNOLOGIES OF FULLY DIGITAL TEXTBOOKS FOR VOCATIONAL EDUCATION

The development process of fully digital textbooks for vocational education mainly involves six stages, including demand analysis, and key technologies mainly include advanced technologies such as artificial intelligence, AR/VR, big data, and blockchain:

4.1 Development Process

The development of fully digital textbooks for vocational education is a systematic project that requires following a scientific and reasonable process to ensure the quality and applicability of the textbooks. The development process mainly includes requirements analysis, framework design, content writing, resource integration, technical implementation, testing and evaluation, and other links, which are interrelated and influence each other.

Requirement analysis is the primary and critical step in the development of digital textbooks. Through in-depth research on vocational education teaching needs, student learning needs, and industry and enterprise needs, it is necessary to clarify the target positioning and functional requirements of digital textbooks. In terms of vocational education teaching needs, there is a must to engage in in-depth communication with teachers in vocational colleges to understand the problems they encounter in the teaching process and their expectations for digital textbooks. Teachers generally express the hope that digital textbooks can provide rich teaching cases and practical projects to meet the needs of vocational education practical teaching. The research on students' learning needs is conducted through questionnaire surveys, student interviews, and other methods to understand their learning habits, interests, and acceptance of digital textbooks. [6] Students tend to prefer interactive and fun digital textbooks, hoping to engage in self-directed and collaborative learning through them. It

is necessary to conduct research on the needs of industry enterprises, communicate with technical and management personnel of relevant enterprises, and understand the latest development trends and talent demand standards of the industry. Enterprises hope that digital textbooks can cultivate students' practical skills and problem-solving abilities, enabling them to quickly adapt to the working environment of the enterprise after graduation.

Framework design is the planning of the overall structure and content framework of digital textbooks based on requirements analysis. It is also necessary to determine the chapter setting, distribution of knowledge points, and division of teaching modules in digital textbooks to ensure the systematic and logical content of the textbooks.

In the framework design of digital textbooks for aircraft component repair, three core modules should be constructed based on CCAR-66 requirements and manufacturer specifications: The first is the basic theoretical module, which includes a 3D detachable component model library, a virtual non-destructive testing system, and a dynamic airworthiness regulation database; The second is the skill training module, which covers typical job card training such as VR repair of engine blades and AR disassembly and assembly instructions for landing gear; The third is an intelligent evaluation system that integrates technologies such as AI standard comparison and troubleshooting decision trees. The framework adopts ATA chapter classification, and each module includes technical diagrams, virtual disassembly and assembly, and defect case libraries, and is updated in real-time with manufacturer technical notices. Through the closed-loop design of "theory-practice-evaluation", it not only meets the teaching requirements of 147 training institutions, but also achieves scene connection with MRO enterprises through digital twin technology, providing students with a high-value component free repeated training platform.

Content writing is the core link in the development of digital textbooks. "The true digital textbook should be the digitized presentation of the textbook content itself, and its charm lies in the novelty, intuitiveness, and innovation of the digitized presentation of knowledge." [7] Taking the content writing of civil aviation English digital textbooks as an example, it is necessary to organize a writing team composed of experienced English teachers from civil aviation colleges, training experts from airlines, and educational technology teams. The content should highlight industry

characteristics, such as pilot English, which should be based on the ICAO English proficiency exam outline and integrated with real land and air communication recordings (such as special case handling examples). The content writing also needs to be organically integrated into the ideological and political content of the curriculum, with a focus on cultivating students' core competencies and guiding them to develop professional awareness, spirit, ethics, and other professional qualities. [8] By comparing Chinese and foreign aviation regulations, there is a must to strengthen the institutional confidence of China's civil aviation safety development. To reflect the writing characteristics, a three-dimensional content structure of "standard terminology-scenario simulation-cultural expansion" can be adopted, and the "rigorous and accurate" professional language habits can be strengthened in real time through an AI voice correction system. Chinese cultural elements (such as English expressions of Chinese characteristic meals) can be naturally integrated into the training of scenario dialogues. This writing mode emphasizes the integration of "professional+ideological and political" content, reflecting the overall goal of cultivating Chinese civil aviation talents with "composite knowledge, diverse abilities, civil aviation literacy, and international perspective".

Resource integration is the integration of various media resources such as text, images, audio, video, animation, VR/AR, etc., enriching the content presentation forms of digital textbooks, and fully digital textbooks to achieve true technological empowerment and diverse integration (see "Figure 5"). By collaborating with professional resource production companies or utilizing open-source resource libraries, high-quality multimedia resources can be obtained. In the development of digital textbooks for airport electrical technology majors, an immersive learning system is constructed by integrating multimedia resources such as 3D models and AR/VR: (1) In terms of technical specifications: it is necessary to integrate ICAO electrical standard documents and IEC standard article databases; (2) In terms of practical resources, there is a must to develop interactive modules such as 3D disassembly models for navigation lighting systems, AR fault diagnosis guidelines for power supply and distribution equipment, and VR inspection simulations for terminal buildings; (3) In terms of case resources, it is also necessary to include typical airport electrical drawings (such as runway lighting circuit diagrams), live action videos of electrical safety operations, and equipment failure animations. Through an intelligent tagging system, text standards, drawing materials, and virtual training are organically connected to form an advanced resource architecture of "theoretical cognition-simulation operation-emergency response", enabling learners to systematically master professional abilities from basic electrical skills to special electrical system maintenance in the virtual airport environment.

Technical implementation is the use of advanced digital technology to digitize content and resources, achieving the functionality and interactivity of digital textbooks. In the technical implementation of college English digital textbooks, an intelligent multimodal interaction architecture is adopted, integrating four core technologies: (1) An intelligent oral practice system based on speech recognition engines (such as iFlytek SDK) to achieve real-time pronunciation correction; (2) NLP-driven personalized reading recommendation engine, adaptive matching of article difficulty; (3) VR English corner developed with WebXR framework, supporting scenario dialogue training; (4) A writing correction system based on the DeepSeek model, providing grammar checking, logical analysis, and rhetorical suggestions. Through technological breakthroughs in multimodal input fusion and cross-cultural scene modeling, the closed-loop design of "intelligent diagnosis-adaptive training-multidimensional feedback" achieves the advancement of abilities from general English to academic English. The platform integrates MOOC resources and supports seamless switching between mobile fragmented learning and PC deep learning scenarios.

Testing and evaluation is the comprehensive testing and assessment of the content, functionality, technical performance, and other aspects of digital textbooks after their development is completed. Teachers, students, and industry experts can be invited from vocational colleges to conduct trials, collect their feedback, and optimize and improve the textbooks. Through testing and evaluation, problems are identified in digital textbooks, such as content errors, incomplete functionality, and poor technical stability. Timely modifications and improvements are made to ensure the quality and applicability of digital textbooks.
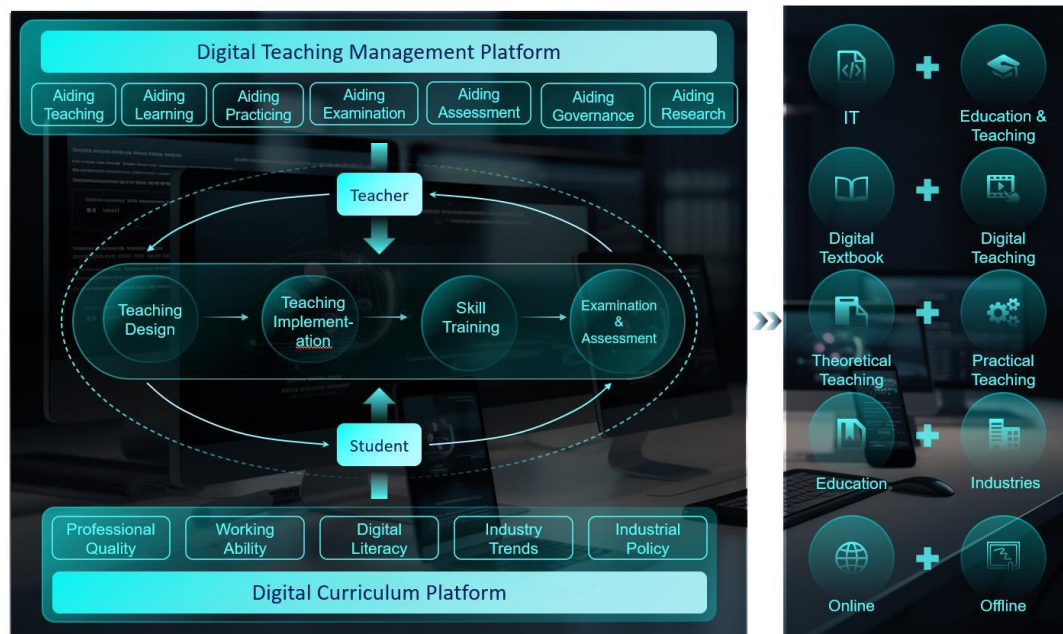
Figure 5 Technological empowerment and multi-integration of fully digital textbooks.

4.2 Key Technology Applications

Artificial intelligence technology has important applications in the development of fully digital textbooks for vocational education, providing strong support for the intelligent and personalized development of textbooks. In terms of personalized learning, artificial intelligence analyzes students' learning data, such as learning progress, answering situation, learning time, etc., to understand students' learning habits and knowledge mastery level, and provide personalized learning paths and content recommendations for students. When students encounter difficulties in the learning process, the artificial intelligence tutoring system can automatically identify the problem and provide targeted answers and tutoring to help students solve the problem. In the digital textbooks of mathematics courses, artificial intelligence systems push targeted practice questions and instructional videos based on students' answer situations to help students consolidate weak points. AI automatically identifies learning difficulties and provides step-by-step solutions and knowledge reinforcement suggestions.

VR and AR technologies have brought immersive learning experiences to digital textbooks, integrating skill training scenarios with real-life situations, allowing students to fully interact and develop their technical abilities and professional qualities. [8] VR and AR technologies have achieved breakthrough applications in digital textbooks for aviation majors. The VR system has built a high-fidelity engine maintenance scenario, where students can immerse themselves in the CFM56 engine disassembly and assembly process, complete tasks such as blade inspection with virtual tools, and receive real-time operation scores. AR technology is innovatively applied to smart airport teaching, where 3D models of luggage systems, energy pipelines, and other invisible facility data are overlaid on a physical sand table through AR glasses. Real time parameters can be viewed through gesture interaction. The "AR Tower Command Simulation System" trains special situation handling capabilities through the fusion of virtual and real flight data. These technological breakthroughs have solved high-risk practical training problems (such as engine hot end maintenance), significantly improved teaching efficiency through multimodal interaction (voice+gesture+eye tracking), and achieved abstract knowledge visualization and complex process operability.

Big data technology provides scientific basis for precise optimization of digital textbooks through multi-dimensional data collection and intelligent analysis. The system utilizes buried point technology to collect real-time interaction data from students (such as click streams, note annotations, test results, etc.), and uses machine learning to construct learning behavior profiles. For example, when the analysis finds that students' retention time for the subjunctive mood exceeds the

benchmark by 35% and the error rate continues to be higher than 60%, the system automatically triggers an optimization mechanism: the first is, through association rule mining, to locate specific problems (such as the confusion scene of the "were-type" subjunctive mood), then to dynamically insert remedial content (such as visual rule graphs, film and television example sentences, AI dialogue exercises), and to intelligently adjusts the order of grammar point explanations, comparing easily confused structures (such as the virtual form of if conditional sentences). Based on data-driven dynamic optimization, textbook content always matches students' cognitive curves, achieving personalized learning. In addition, the textbook uses heatmaps to reveal the differences in understanding among students in different regions and assist in adjusting regional teaching strategies.

Blockchain technology provides innovative copyright protection and data security solutions for digital textbooks. The copyright management system based on smart contracts permanently links textbook metadata (author information, authorization terms, etc.) and combines IPFS to achieve decentralized storage, ensuring that the information is tamper proof. Zero Knowledge Proof Technology (ZKP) supports anonymous copyright verification, balancing privacy and anti-piracy. In terms of data security, a hybrid architecture of consortium chain and private chain is adopted, combined with homomorphic encryption technology, to achieve analyzable processing of encrypted data. The new generation of educational blockchain is based on Algorand consensus mechanism and supports high concurrency processing of learning records (5000+TPS), balancing efficiency and low energy consumption. In addition, NFT technology is used for textbook content authentication, and the full traceability is achieved through NFT certification modified by knowledge points. This architecture complies with GDPR regulations and provides a trusted technological foundation for the digital education ecosystem. At present, these technologies have been piloted in some educational institutions and are gradually being promoted and applied.

5. CONCLUSION

The development of fully digital textbooks in vocational education marks a new stage of deep integration of educational informatization. By integrating cutting edge technologies such as artificial intelligence, VR/AR, big data and

blockchain, digital textbooks have upgraded from simple electronic resources to intelligent and personalized learning ecosystems. It not only breaks through the temporal and spatial limitations of traditional textbooks, but also provides rich possibilities far beyond traditional teaching through immersive training, dynamic content optimization, precise learning analysis and other functions, "providing rich possibilities for practicing core educational concepts such as 'returning to production and life' and 'learning by doing' in vocational education." [8]

In the future, with the maturity of technologies such as 5G, digital twins, and generative AI, digital textbooks will present three major trends: The first is deep scene based training, through high fidelity virtual simulation training, to achieve seamless connection with real work environments; The second is being highly intelligent, relying on AI learning assistants to achieve adaptive teaching throughout the entire process; The third is ecological synergy, building a dynamic knowledge updating mechanism for school enterprise linkage. However, the application of technology still needs to be based on the essence of education. In the development process, it is necessary to start from humanism, "taking the existing knowledge, experience, and physical and mental development laws of different individuals as references, with the goal of promoting the cognitive transformation process of individuals to achieve holistic physical and mental development", to ensure that technology serves the goal of talent cultivation. [9] At the same time, attention should be paid to the issue of digital divide, and education equity should be promoted by optimizing new digital infrastructure and strengthening digital literacy training.

The innovative development of digital vocational education textbooks requires continuous collaboration among educators, technical experts, and industry enterprises. Only by deeply integrating advanced technology with educational laws and industry demands can people build a smart learning system that truly meets the requirements of the future workplace and provide strong support for cultivating high-quality technical and skilled talents. This process will not only reshape the form of vocational education, but also contribute Chinese solutions to the development of global digital education.

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