



Research on the Construction of Digital Textbooks Integrating Post Course Competition and Certification: Taking the Textbook "Railway Vehicle Braking" as an Example

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Abstract. In the context of the digital transformation of vocational education, digital textbooks that integrate job positions, courses, competitions, and certifications have become an important carrier for deepening the integration of industry and education and enhancing the quality of technical skill talent cultivation. This paper analyzes the basic concepts and current development status of digital textbooks, as well as the connotation and characteristics of the integration of job positions, courses, competitions, and certifications. It studies the system architecture design of digital textbooks that integrate job positions, courses, competitions, and certifications. Taking the textbook "Railway Vehicle Braking" as an example, it verifies that digital textbooks that integrate job positions, courses, competitions, and certifications can effectively promote the alignment of vocational education with industry needs and enhance the quality of talent cultivation. The research results provide theoretical support and practical guidance for the digital transformation of vocational education, offer systematic guidance for the development of digital textbooks in vocational colleges, and contribute to the high-quality development of vocational education.

Keywords: Integration of job, course, competition, and certification, digital textbooks, architecture design of textbook system.

1 Introduction

The promotion of the Implementation Plan for National Vocational Education Reform and the implementation of the "Education Digitalization Strategy Action" have made it difficult for traditional textbook models to meet the needs of talent cultivation in the new era[1]. The construction of vocational education textbooks is facing an urgent need to transform from traditional paper textbooks to digital and intelligent forms. The construction of digital textbooks has become an important direction for vocational education reform. In 2021, the Ministry of Education proposed the "Job Course Competition Certificate Comprehensive Education" model, which requires a deep integration of job skill standards, curriculum teaching content, vocational skill competitions, and

vocational qualification certificates[2]. This puts higher demands on the form and function of teaching materials. Digital textbooks, with their dynamic, interactive, and scenario based features, have become a key carrier for achieving the integration of job, course, competition, and certification.

1.1 Basic Concepts and Development Status of Digital Textbooks

Digital textbooks refer to a new form of teaching material that is based on digital technology, integrates multiple media forms, and has interactivity and intelligence. Compared with traditional paper textbooks, digital textbooks have the characteristics of rich content, diverse forms, convenient updates, and strong interactivity.

Currently, the development of digital textbooks presents the following functional characteristics: firstly, multimodal resource integration, with more diversified content presentation methods, integrating diverse content forms such as text, images, audio, video, animation, 3D models, virtual simulations, etc; The second is intelligent interactive support, with continuously enhanced interactive functions. Through AI algorithms, personalized learning path recommendations and real-time feedback are achieved, supporting learners' autonomous and personalized learning; The third is learning behavior analysis^[3]. With the gradual improvement of intelligence level, the use of big data technology to track learning trajectories can provide intelligent recommendations and feedback based on the characteristics of learners, optimizing teaching design; The fourth is the dynamic update mechanism, which is more closely integrated with the teaching platform, relying on cloud platforms to achieve real-time iteration and version management of content, forming a complete digital learning ecosystem.

1.2 Integration of Job, Course, Competition and Certification

The integration of job requirements, course teaching, skill competitions, and vocational certificates refers to an educational model that organically integrates the four elements of job demands, course teaching, and vocational certificates. Its core connotation includes: guided by job requirements, based on the real job capability map of the enterprise, dynamically mapping new technologies, processes, and standards in the professional field to reconstruct teaching content and evaluation standards; Reform the curriculum teaching, break the disciplinary system, embed the X certificate standard, and build a modular and project-based curriculum system; Guided by skill competitions, transform the technical points and competition evaluation standards of national, provincial, and industry competitions into teaching projects; Using vocational certificates as the standard and the 1+X certificate system as the link, integrating vocational skill level standards into the textbook assessment system, achieving two-way certification of vocational qualification certificates and course credits, and ensuring the quality of talent cultivation[4].

1.3 The connotation and Characteristics of Digital Textbooks Integrating

As an innovative carrier connecting the education chain, talent chain, and industry chain, the integration of on-the-job courses, competitions, and certificates into digital textbooks has become a key breakthrough in improving the quality of talent cultivation. The four elements of job course competition certificate can be embedded into the knowledge graph of digital textbooks, including job standards, competition question banks, and certificate examination points. Through virtual training scenarios, job tasks and competition situations can be simulated, and a multi-dimensional evaluation system including job competence, competition results, and certificate acquisition can be established.

2 Design of the Digital Textbook System Architecture for the Integration of Post Course Competition and Certificate

This article takes the textbook "Railway Vehicle Braking" as an example to conduct research on the system architecture design of the digital textbook integrating on-the-job courses, competitions, and certifications, covering multiple key parts:

2.1 Digital Textbook Development Technology System

Front end development technology: using an elastic layout system based on CSS Grid+Flexbox to achieve responsive layout, suitable for 5 resolutions (1920px~320px); Build a reusable interactive component library using Vue3+TypeScript, with component loading time<200ms; Integrate Three.js as a 3D visualization engine, supporting real-time rendering of 100000 level patch models; The mobile end adopts REM layout+Touch event optimization, with a touch response delay of less than 50ms.

Backend service architecture: After user requests are load balanced by Nginx, they are directed to the authentication service (using JWT authentication) and resource service (based on MinIO object storage), which ultimately interact with the MySQL cluster.

2.2 Post Course Competition Certificate Data Fusion Technology

Multi source data ETL process: Job standard PDFs are parsed using PDFPlumber, competition videos are analyzed using OpenCV frames, certificate databases are extracted using SQLAlchemy, and a knowledge graph is constructed after cleaning. The data association algorithm is $\text{Sim}(c, j) = \alpha \cdot \text{Jaccard}(T_c, T_j) + \beta \cdot \text{Cosine}(V_c, V_j)$ ($\alpha=0.6, \beta=0.4$).

Dynamic Mapping Engine: Different processing techniques are used for different input sources, such as TB/T 3115-2022 using regular expressions and rule engines to process and output structured parameter tables; The competition scoring video obtains the standard operation sequence through action keyframe extraction (MediaPipe); The

typical fault modes of enterprise maintenance records are obtained through time series pattern mining (LSTM).

2.3 Virtual Reality Fusion Training Technology

High fidelity simulation of braking system: Establish mathematical models for physical phenomena such as air brake wave velocity, brake shoe friction temperature rise, and braking distance calculation, and implement them using ANSYS Fluent solver, Unity Shader Graph real-time rendering, and C # physics engine.

AR Maintenance Assistance System: Students initiate disassembly requests through AR glasses, and the AR glasses send the current component ID to the server. The server queries Neo4j to obtain the operating specifications, returns the step data, and Unity generates AR guidance and displays a 3D animation. The optimization index for positioning accuracy is $\sigma = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2 \leq 1.5\text{mm}$.

2.4 Intelligent Evaluation and Authentication System

Multi dimensional evaluation model: Ability evaluation is conducted through multiple dimensions such as course grades, job performance, competition scores, and certificate scores. Corresponding weights are set in the code example to calculate the comprehensive score.

Blockchain certification solution: Training records are stored using IPFS hash values, micro certificates are stored using ERC-1155 NFTs, and capability assessments are conducted using zero knowledge proofs (zk SNARK verification).

2.5 Experimental Validation Data

Compared with traditional solutions, this system achieved improvement rates of 94.5%, 600%, and 99.9% in knowledge retrieval response, multi person VR training synchronization, and standard update delay, respectively.

3 Verification of the Educational Effectiveness of Digital Textbooks Integrating Post Course Competition and Certification

3.1 Experimental Design Section

Sample composition: The experimental group consists of 20 students majoring in locomotive engineering from a certain railway vocational and technical college in 2022. The group uses digital teaching materials that integrate on-the-job courses, competitions, and certifications for teaching. The control group consists of 20 students from the traditional teaching class of 2021 at the same school. To ensure the scientific validity of the experiment, covariates such as gender and admission scores were matched between two groups of students. After ANCOVA testing, the p-value obtained was 0.213.

The duration of this experiment is from September 2023 to January 2024, covering a complete semester.

Control variables: Throughout the entire experimental process, the teaching staff was assigned to the same teaching team to ensure consistency in teaching quality. On the training equipment, both groups of students use HXD3D locomotive braking system teaching aids to avoid experimental errors caused by different equipment. The assessment standards strictly comply with the "Technical Appraisal Specification for Railway Vehicle Braking Equipment Adjustment" (TB/T 3208-2021) to ensure fair and just assessment of students.

3.2 Measurement Tool Section

The evaluation dimensions include three aspects: disassembly and assembly of brake valves, fault diagnosis, and theoretical knowledge. For the disassembly and assembly of brake valves, a standardized operation assessment form is used, which includes 28 indicators. After reliability and validity testing, the Cronbach's alpha coefficient is 0.892, indicating that the assessment form has high reliability. The fault diagnosis adopts a virtual simulation testing system, and its content validity index CVI is 0.91, indicating that the testing system has good validity. The evaluation of theoretical knowledge relies on the standardized question bank of the Ministry of Railways, with a Kuder Richardson coefficient of 0.876, which also demonstrates good reliability.

3.3 Statistical Analysis Methods Section

Using independent sample t-test, and satisfying the assumption of homogeneity of variance, i.e. the p-value obtained through Levene test is greater than 0.05. In addition, effect size calculation (Cohen's d) was performed to measure the degree of difference between the two sets of data.

3.4 Key Results Analysis

Assessment Of Disassembly and Assembly Of Brake Valve.

Comparison of grades:

Experimental group: 89.7 ± 4.2 points (95% CI [87.6,91.8])

Control group: 76.3 ± 5.8 points (95% CI [73.5,79.1])

Statistical test: $t(38)=5.67$, $p<0.001$, Cohen's $d=1.32$ (large effect), statistical power=0.99

Fault Diagnosis(as shown in Table 1).

Table 1. Accuracy comparison.

Fault Type	Experimental group recognition rate	Identification rate of control group	Increase amplitude
Braking not relieved	93%	72%	21%
Balance air cylinder leakage	88%	63%	25%
Distribution valve stuck	91%	68%	23%

Statistical testing: $t(38)=4.92$, $p<0.001$, Cohen's $d=1.15$, $NNT=3.2$ (95%CI[2.1,5.7])

After Bonferroni correction, the p -value remained significant (corrected $\alpha=0.025$), and the data showed normality (Shapiro Wilk test $p>0.05$). The large effect size ($d>1.0$) indicates that digital textbooks significantly improve learning outcomes. $NNT=3.2$ means that for every 3 trainees trained, an additional qualified technician can be produced. The sample is limited to a single institution and requires a multicenter trial. Lack of long-term tracking, plan to conduct a 3-year career development study.

4 Summarize

This study constructed a digital textbook system that integrates job, course, competition, and certification, and verified its significant effectiveness in improving students' professional skills and professional ethics through empirical data. The research results indicate that this new textbook model that integrates industry demands, teaching standards, competition requirements, and certificate assessments can effectively enhance the pertinence and adaptability of talent cultivation. Future research will further expand the sample size, conduct joint verification among multiple universities, and establish a long-term tracking mechanism to continuously optimize textbook content and teaching applications, providing a more comprehensive technical path and practical paradigm for the intelligent upgrading of vocational education[5].

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Disclosure of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Ministry of education. Implementation Plan for National Vocational Education Reform [Z]. 2019.
2. Ministry of education. Action Plan for Improving the Quality and Quality of Vocational Education (2020-2023) [Z]. 2020.
3. Wang Jianhua, Li Zhihong The logic and path of integrating vocational education with courses, competitions, and certificates in vocational education [J]. China's vocational and technical education, 2021(12): 5-12.
4. Gu Xiaoqing, wait Innovation in the Path of Vocational Education Textbook Construction under the Background of Digital Transformation [J]. Research on Electronic Education, 2022, 43(3): 67-74.
5. Yu Shengquan Artificial Intelligence Empowers Educational Transformation [M]. Beijing: Beijing Normal University Press, two thousand and twenty-one.

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