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Reform and Exploration of the "Three-Stage, Five-Dimensional" Smart Teaching Model in the Course "Rail Transit Safety Management"

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Abstract

In response to the challenges faced by traditional safety management courses in the context of the intelligent transformation of the rail transit industry—such as outdated teaching resources, rigid teaching methods, and fragmented evaluation systems—this paper proposes and implements a "three-stage, five-dimensional" smart teaching model. This model follows a three-stage teaching process: pre-class autonomous learning, in-class in-depth inquiry, and post-class precise review. It establishes a five-dimensional education objective system covering knowledge acquisition, skill development, competency enhancement, technological innovation, and value guidance. The model also develops three-dimensional teaching resources, designs project-based teaching plans, and introduces a multi-dimensional process-oriented evaluation system, while deeply integrating ideological and political education into technical application scenarios. Practical results show that this model effectively improves students' intelligent technology application skills, risk prediction ability in complex scenarios, and professional responsibility. It provides a replicable paradigm for the digital transformation of application-oriented engineering disciplines.

Keywords

Rail transit safety management; teaching reform; three-stage five-dimensional smart teaching model; ideological and political education in courses.

1. Introduction

With the deepening implementation of the national strategy for building China's strength in transportation and the accelerating digital transformation of the rail transit industry, the traditional course "Rail Transit Safety Management" faces serious challenges. Technological advances in the industry—from fully automatic driving to digital twin operation and maintenance—require safety management personnel to have data-driven and intelligent prevention capabilities. However, existing courses can no longer fully meet the needs of talent cultivation in the new era[1-2]. The main problems in the current course are fourfold: first, the teaching content lags behind industry developments; second, teaching methods rely mainly on one-way lectures, lacking immersive practice in complex scenarios; third, the evaluation system emphasizes results over processes, making it difficult to accurately measure students' engineering practice and innovation abilities; fourth, the integration of ideological and political education with professional knowledge is insufficient. Based on these issues, this paper proposes a "three-stage, five-dimensional" smart teaching model, aiming to create a new teaching ecology featuring three-dimensional resources, precise instruction, scientific evaluation, and deep integration of ideological and political education.

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2. Theoretical Construction of the "Three-Stage, Five-Dimensional" Smart Teaching Model

The "three-stage, five-dimensional" smart teaching model is based on the Outcome-Based Education (OBE) philosophy. It takes students' ability outcomes as the orientation and uses smart teaching methods to deeply optimize and restructure traditional teaching approaches.

2.1. Data-driven three-stage teaching structure

Relying on a smart teaching platform, the model restructures a whole-process teaching loop driven by data collection and diagnosis[3-5].

Stage one: pre-class autonomous learning and learning diagnosis. Teachers use the platform to assign structured pre-class task packages. The platform records learning behaviour data in real time and automatically generates a learning profile for each student, enabling data-driven pre-class diagnosis.

Stage two: in-class in-depth inquiry with virtual-actual integration. A combination of light interaction and deep immersion is adopted. In theoretical discussions, case studies are used to guide group debates through a chain of questions. In complex scenario analysis, simulation software such as Pathfinder and Vensim PLE is introduced. Through role-playing, students deepen their understanding in cycles of trial, feedback, and revision.

Stage three: post-class precise review and dynamic optimisation. The platform automatically aggregates process data and generates a learning diagnostic report. Teachers adjust their teaching design accordingly, forming a continuous optimisation loop of diagnosis, intervention, and feedback.

2.2. Interconnected five-dimensional education objective system

The five dimensions of the educational objective system are: knowledge acquisition, skill development, competency enhancement, technological innovation, and value guidance. In the knowledge dimension, students are required to master core theories and principles of intelligent technology. In the skill dimension, the focus is on applying intelligent technologies and coordinating responses in complex scenarios. The competency dimension emphasises innovation in engineering practice and teamwork. The technology dimension stresses the use of digital tools and the application of cutting-edge technologies. The value dimension embeds the principle of "people first, life foremost" throughout the course, strengthening professional responsibility and craftsmanship spirit[6-7].

3. Reform Implementation Pathways and Innovative Measures

3.1. Building integrated, application-oriented three-dimensional teaching resources

A four-pronged approach transforms teaching resources from static and single to dynamic and three-dimensional, as shown in Figure 1. Basic resources focus on structured integration and dynamic updating, drawing on syllabi, courseware, case collections, audio-visual materials, and quality MOOCs on the smart teaching platform. Practical resources use a dual-wheel approach combining physical training and virtual simulation, covering various complex scenarios to achieve virtual-actual complementarity. Interactive evaluation resources emphasise data-driven, closed-loop feedback, exploring the teaching support functions of smart mobile apps to facilitate ability profiling and precise improvement. Ideological and political elements are integrated with the goal of value inculcation and responsibility cultivation, drawing on safety warning videos, typical cases, online topics such as the ethics of intelligent technology, and social practice activities such as metro volunteering. Through three pathways—ethical analysis

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in technical explanations, prevention orientation in case studies, and humanistic care in scenario drills—the course achieves an organic integration of professional education and ideological and political education.

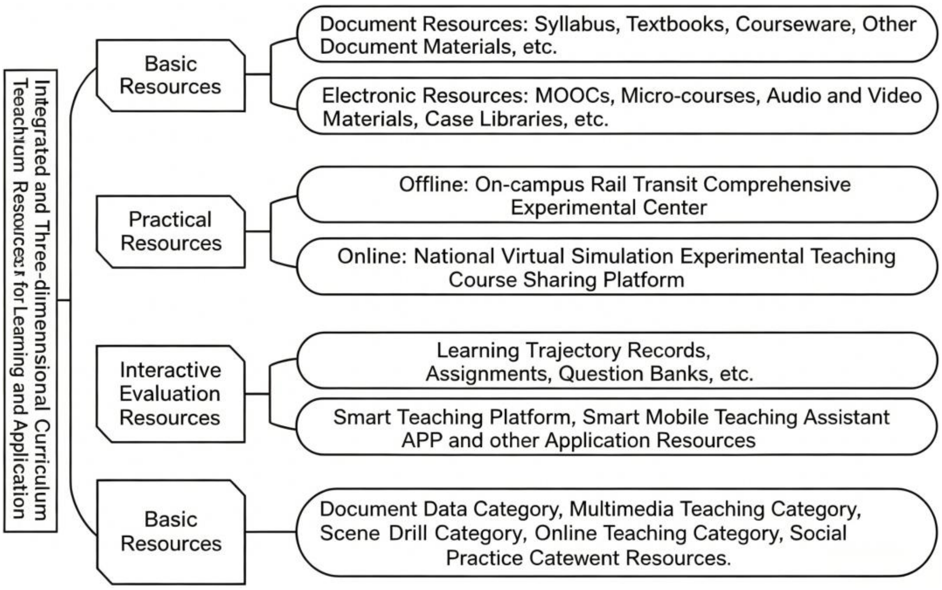

Fig. 1: Design of the three-dimensional course teaching resources

3.2. Creating a smart-enabled, precise inquiry classroom

By integrating project-based teaching design with blended learning, the course adopts a precise classroom form that combines online autonomous inquiry, offline in-depth discussion, and cross-platform interaction. This systematically cultivates students' engineering practice and innovation abilities as well as their ideological and political literacy.

First, through the progressive project-based teaching design shown in Figure 2, the course content is divided into four modules: Project 1–Analysis and discussion of rail transit safety accidents; Project 2–Learning and application of rail transit safety analysis methods; Project 3–Design and scenario drills of rail transit emergency response plans; Project 4–Ideological and political education. Different teaching methods are matched to each project, forming a hierarchical and progressively advancing training system.

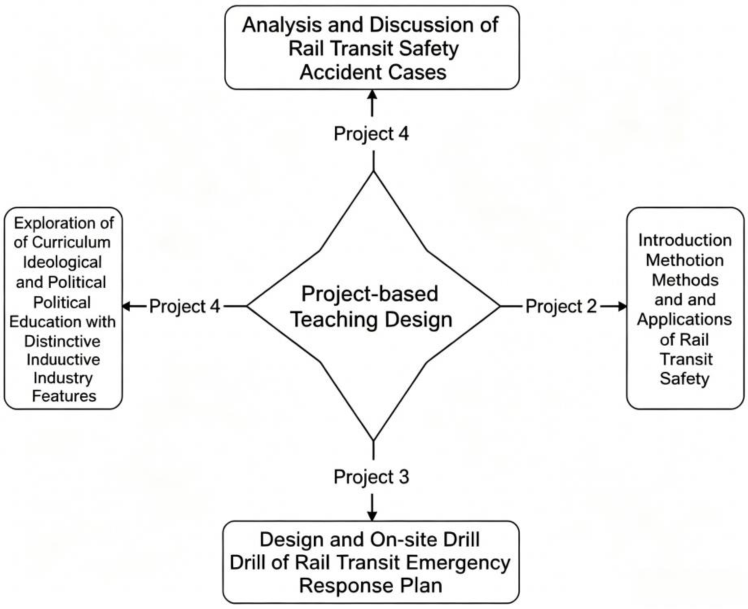

Fig. 2: Project-based teaching design for the course

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The teaching design for Project 1 is shown in Figure 3. The learning objectives focus on the ability to use theoretical knowledge to solve practical problems and on cultivating an innovative mindset. A combination of case-driven and problem-driven approaches is adopted. Through a flipped classroom, the project achieves pre-class intelligent learning, in-class collaborative inquiry, and post-class output of results.

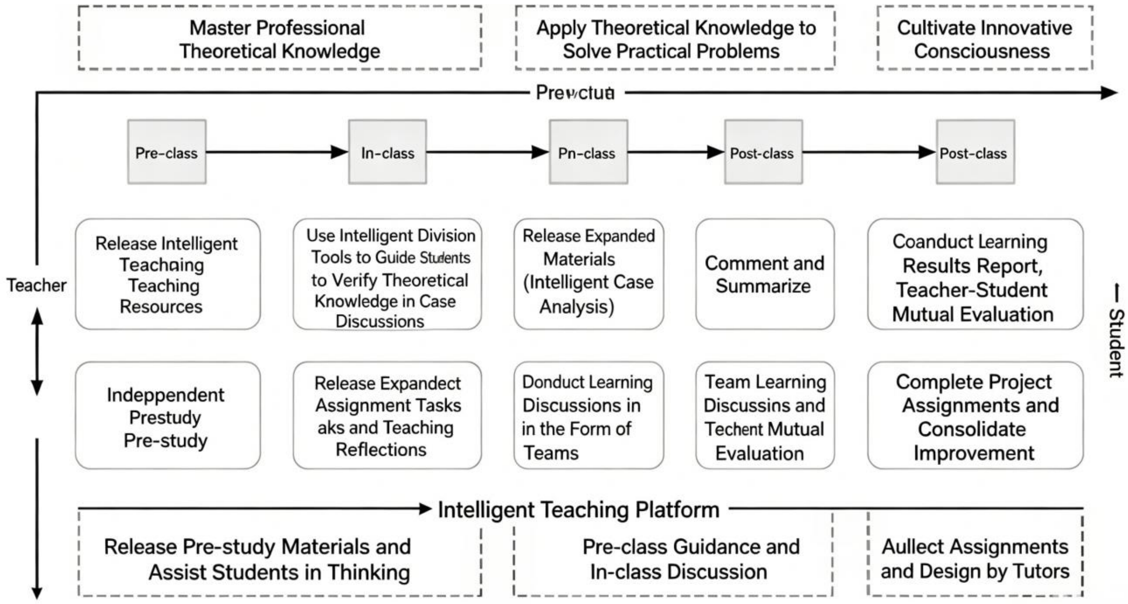

Fig. 3: Teaching design for Project 1

Project 2: The learning objective is to strengthen innovative thinking in engineering practice. Using an intelligent dynamic demonstration system, the evolution of rail transit safety accidents is simulated, visually showing the relationship between theoretical calculations and real-world scenarios.

The teaching design for Project 3 is shown in Figure 4. The learning objective focuses on coordinated response capabilities in complex scenarios. Using both physical and virtual scenarios, students take on different roles and work collaboratively to complete scenario design and drills, thereby strengthening their engineering practice and innovation abilities through cycles of simulation, feedback, and optimisation.

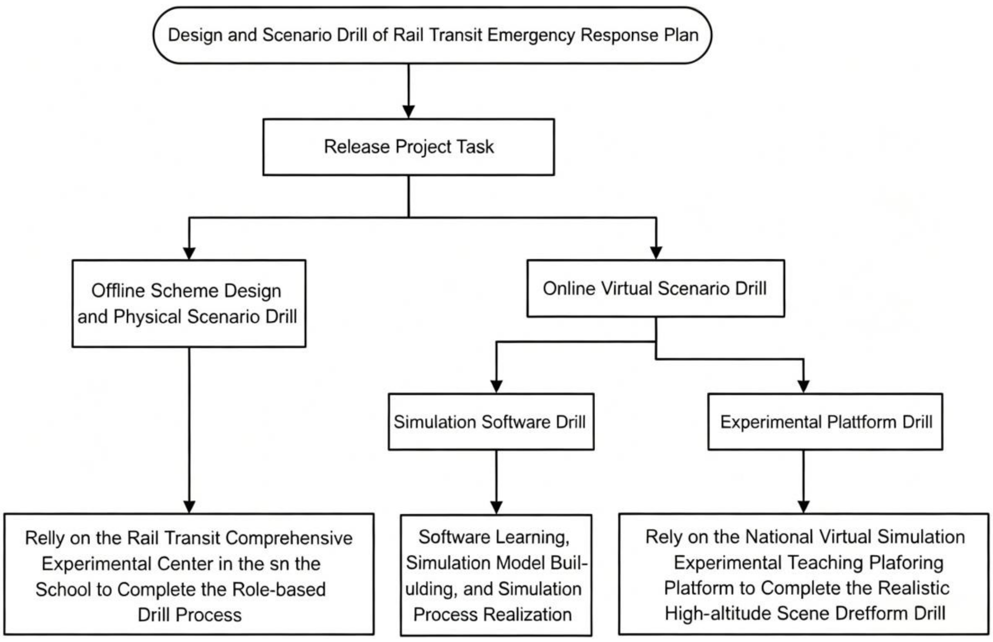

Fig. 4: Implementation process of Project 3

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Project 4: The learning objective is to comprehensively improve students' ideological and political literacy. Ideological and political elements are integrated into the first three projects throughout the process. Through tasks such as ethical analysis in technical explanations, prevention orientation in case studies, and humanistic care in scenario drills, the values of "people first, life foremost" are embedded, along with guidance on professional responsibility and social responsibility.

3.3. Establishing a multi-dimensional process-oriented evaluation system

Centred on ability outcomes, the evaluation system combines online data with offline performance, quantitative analysis with qualitative assessment, and assesses students from three dimensions: knowledge acquisition, competency enhancement, and skill development. The resulting multi-dimensional process-oriented evaluation system[8] is shown in Table 1.

Table 1: Multi-dimensional process-oriented evaluation system

Evaluation Dimension	Assessment Indicators	Assessment Content and Methods	Data Sources
Knowledge acquisition 30%	Theoretical application	Completion of online learning, accuracy of online quizzes, contribution to discussions (quality of comments, frequency of interaction)	Smart platform learning behaviour logs, discussion forum text analysis
Competency enhancement 30%	Ideological and political literacy	Analysis of safety responsibility cases (logical rigour, value orientation), statement of professional values (sense of responsibility, humanistic care)	Video recordings of group work
Skill development 40%	Practical innovation ability	Accuracy of risk identification in different scenarios, standardisation of emergency response procedures, efficiency of multi-role coordination	Virtual simulation platform operation records, project presentations
	Outcome summarisation	Case analysis report (problem identification and analysis), solution design (creative problem-solving), course paper (theoretical application and practical value)	Peer assessment, inter-group assessment, instructor scoring

3.4. Deepening a new paradigm of value-led professional education

Guided by the "Guidelines for the Ideological and Political Construction of University Courses", this model closely follows a three-level logic covering the course itself, the profession, and the nation. Through deep extraction of ideological and political elements and their integration into multiple learning scenarios, course-based ideological and political education is transformed from an add-on task into an inherent component. This promotes a shift from simple physical addition to true chemical fusion between ideological and political education and professional education, achieving simultaneous and resonant development of professional knowledge transmission and value guidance, with an unobtrusive educational effect[9-10].

First, extraction of ideological and political elements: refining the value core from multiple perspectives. Following the principle of balancing explicit and implicit content and natural integration, and drawing on the course's characteristics and the profession's attributes, the model extracts the safety concept of "people first, life foremost" from the perspective of industry mission. It also extracts the spirit of innovation and commitment to serving the nation

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through science and technology from the perspective of technological ethics, and strengthens a sense of professional responsibility from the perspective of occupational integrity.

Second, integration pathways: coordinated embedding through scenarios and tasks. Ideological and political elements are deeply embedded in both physical and virtual scenario drills. For example, in a virtual simulation of emergency response to a stampede in a large passenger flow, in addition to operational procedure training, a module displaying casualty data visualisation and social rescue value prompts is added to guide students to reflect on the humanistic responsibilities behind technical operations. A safety responsibility simulation project is also designed, in which students, acting as newly hired safety engineers, write a safety responsibility letter and participate in a scenario defence on topics such as a passenger refusing to cooperate with security checks. Through role immersion and solution design, the sense of responsibility is translated into concrete action logic, deepening professional mission.

4. Implementation Outcomes and Reflections

4.1. Analysis of teaching practice outcomes

To verify the effectiveness of the "three-stage, five-dimensional" teaching model, the course team conducted a pilot teaching session in the Traffic Engineering programme. Teaching practice showed that the model achieved positive results in improving student engagement, knowledge mastery, and higher-order abilities.

(1) Student classroom participation and learning investment increased significantly. Tracking data collected via the smart teaching platform are shown in Figure 5.

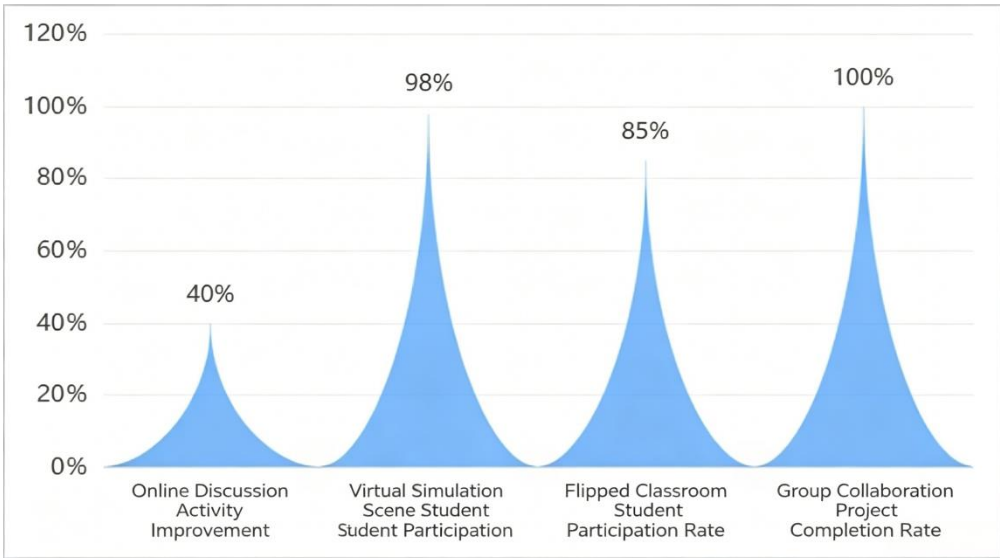

Fig. 5: Data tracking from the smart teaching platform

(2) Students' knowledge mastery and application ability improved significantly. More than 90% of students were able to complete class summaries and homework accurately. The average course score increased by 15% compared with the previous academic year.

(3) Students' higher-order abilities and professional competencies were cultivated. The reasonableness of students' emergency response plan designs improved by 25%, and the accuracy of risk identification increased by 30%. Students were able to use simulation software to adjust parameters and compare changes in risk levels before and after the implementation of prevention measures, thereby developing a preliminary data-driven safety decision-making mindset. The teaching satisfaction survey showed that 95% of students recognised the new model and generally reported a significantly enhanced sense of professional mission and awareness of the principle that "safety is never a small matter".

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4.2. Reflections and diagnosis of problems

Although the course reform has achieved initial results, several common problems still emerged during implementation, mainly in the following four areas:

(1) Insufficient depth of cross-course knowledge integration. In practical case analysis, students were still relatively unfamiliar with applying knowledge from previous courses, often remaining at the level of simple recall and failing to fully explore the deeper logical connections between prerequisite courses and safety management. In the continuous improvement of the course, a "Handbook of Prerequisite Courses and Their Links to Rail Transit Safety Management" will be developed, systematically identifying knowledge points and application scenarios from prerequisite courses that are relevant to safety management. More in-depth analysis questions based on cross-course knowledge will be designed during classroom teaching to guide students towards building a cohesive knowledge system that integrates concept recognition, factor analysis, and systematic prevention.

(2) Imperfect real-time quantitative assessment tools. In real-time classroom assessment, it is currently difficult to accurately grasp every student's mastery of core skills, leading to insufficiently targeted teaching interventions. In the continuous improvement process, specific quantitative indicators will be designed, and a real-time quantitative assessment module will be developed on the Chaoxing Learning platform to generate personalised and class-level ability profiles.

(3) Need to strengthen integration of cutting-edge technologies. Currently, the teaching of artificial intelligence technologies remains mostly at the level of case demonstrations and principle explanations, with limited hands-on opportunities for students. The course improvement plan includes upgrading the virtual simulation experiment platform with VR/AR technologies and adding practice sessions with simple AI tools, allowing students to deepen their understanding of abstract theories and complex processes through cycles of trial, feedback, and revision.

5. Conclusion

The practical exploration of the "three-stage, five-dimensional" smart teaching model in the "Rail Transit Safety Management" course has effectively addressed the problems of outdated resources, rigid teaching methods, and fragmented evaluation systems in traditional teaching. By building a three-dimensional teaching resource system, innovating blended smart teaching methods, establishing a multi-dimensional process-oriented evaluation system, and deepening the integration of ideological and political education, the model has significantly improved students' comprehensive abilities and professional competencies. The successful implementation of this model provides a useful reference for the digital transformation of similar courses, and has both theoretical and practical value. In the future, the course team will continue to deepen teaching reforms and improve the smart teaching system, contributing to the cultivation of high-quality, versatile rail transit talents suited to the digital economy era.

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