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AI-Empowered "Job-Course-Competition-Certificate" Integrated "Four-Dimensional Integration and Five-Stage Progression" Teaching Model Research for Higher Vocational Engineering Courses

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Abstract: Driven by the dual forces of digital transformation in vocational education and the rapid advancement of artificial intelligence technologies, the integrated "Job-Course-Competition-Certificate" (JCCC) education model has become a central direction for higher vocational education reform. However, current higher vocational engineering courses generally face three practical dilemmas: disconnection between teaching content and job requirements, fragmented application of AI technologies, and a monolithic evaluation system. Grounded in constructivist learning theory and industry-education integration theory, this study takes engineering courses in the Cost Engineering major as its practical context and constructs an AI-empowered teaching model based on the "Four-Dimensional Integration and Five-Stage Progression" framework. The model restructures teaching content through the four-dimensional integration of job requirements, course content, competition standards, and certificate criteria alongside AI technologies, optimizes the teaching process through the five progressive stages of context creation, task-driven learning, application-driven learning, practical drill, and outcome presentation, and leverages AI tools such as DeepSeek to enable whole-process empowerment encompassing learning diagnosis, resource generation, and intelligent evaluation. Practical implementation demonstrates that this model effectively enhances students' learning initiative, improves job competency, and increases certificate pass rates, providing a replicable practical paradigm for the intelligent teaching reform of higher vocational engineering courses.

Keywords: AI empowerment; Job-Course-Competition-Certificate integration; Higher vocational engineering courses; Four-Dimensional Integration and Five-Stage Progression; Teaching model innovation

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1. Problem statement

With the successive introduction of policies such as the Opinions on Deepening the Reform of the Modern Vocational Education System and the Vocational Education Digitalization Action Plan (2024–2026), the integrated "Job-Course-Competition-Certificate" education model has become a core direction for vocational education reform. In 2025, the Chongqing Municipal Education Commission issued the Notice on Accelerating the Advancement of "Artificial Intelligence+" to Enhance the Key Educational Capabilities of Vocational Colleges, requiring all vocational institutions to "introduce domestically developed artificial intelligence software and models into core professional courses and accelerate the formation of an 'artificial intelligence+' curriculum system." Against this policy background, how to deeply integrate artificial intelligence technologies into the JCCC teaching practice has become an urgent issue for higher vocational education.

Current higher vocational engineering courses face three structural contradictions. First, the disconnection of JCCC elements—course content is significantly detached from actual job requirements, skill competition standards, and professional certificate criteria, resulting in a mismatch between talent cultivation and industry needs. Second, fragmented AI application—the use of artificial intelligence in teaching mostly remains at the level of instrumental assistance in isolated segments, failing to achieve deep integration throughout the entire teaching workflow. Third, a monolithic evaluation system—excessive reliance on summative assessment, lacking comprehensive evaluation of students' professional competencies, process performance, and literacy development. For engineering courses in particular, the traditional "teacher demonstration—student imitation" teaching model can no longer meet the new demands of enterprises for composite technical talents in the context of intelligent construction. Therefore, there is an urgent need to construct a systematic teaching model that deeply embeds AI technologies throughout the entire JCCC integration process.

2. Theoretical foundations and literature review

2.1. Theoretical framework

The theoretical foundation of this study rests on two pillars. Constructivist learning theory emphasizes that knowledge is actively constructed through collaboration and reflection in authentic contexts, requiring instructional design to create problem scenarios that approximate real work environments and guide students to complete knowledge construction while solving practical problems. Industry-education integration theory advocates the construction of a "demand—teaching—feedback" dynamic closed loop, achieving precise alignment and synchronous iteration between educational supply and industry demand. The intersection of these two theories lies in: taking real industrial problems as the starting point of learning contexts, using AI technologies as mediators for contextualized transformation and personalized support, and forming a "problem-driven → AI-enhanced transformation → competency feedback to industry" bidirectional empowerment logic.

2.2. Research progress on JCCC integration

Since the JCCC comprehensive education model was proposed at the 2021 National Vocational Education Conference, substantial research has accumulated. Zhang Huiqing et al. [1] systematically analyzed the practical problems and implementation pathways of the integrated JCCC education model. In the field of civil engineering, researchers have constructed a "four-in-one" talent cultivation model by restructuring curriculum systems, deepening school-enterprise collaboration, strengthening skill competitions, and aligning with professional certificates, using Cost Engineering as a case study [2]. Studies on blueprint reading courses indicate that JCCC integration can effectively enhance teaching effectiveness [3]. In the area of practical training reform for Cost Engineering, scholars have proposed reform pathways such as "restructuring the curriculum based on job positions, using competitions to stimulate teaching innovation, and integrating certificates to enhance value anchoring" [4]. Deng Wei et al. systematically elaborated on the specific implementation methods of the "Four Integrations, Five Progressions, Three Co-Educations" teaching model using relevant courses as examples, including teaching content restructuring, virtual experimental environment setup, and project-based practical task design, providing important methodological references for this study [5–9]. However, existing research predominantly focuses on curriculum content reorganization and teaching method improvement, with few studies incorporating AI technologies as a systematic variable in the design of JCCC-integrated teaching models.

2.3. Research status of AI-empowered teaching

In recent years, research on AI-empowered vocational education has gradually deepened. Lü Mingzhu proposed a "virtual simulation + cloud classroom" JCCC-integrated teaching model, introducing virtual simulation technology to construct training environments and leveraging cloud classrooms to achieve integrated alignment of jobs, courses, competitions, and certificates, while optimizing teaching resources and dynamically adjusting teaching strategies through AI technologies [5]. Gui Fang et al. systematically discussed how digital-intelligent integration can empower JCCC education from three dimensions: theoretical logic, coupling mechanisms, and practical pathways [6]. Zhao Ye constructed an AI-driven JCCC-integrated evaluation system, developing evaluation indicators across four dimensions: job competency, course learning ability, competition innovation capacity, and certificate recognition [7]. Shen Min et al. constructed a "Three Co-Educations, Four Integrations, Five Progressions" industry-education integration teaching model for vocational education based on Outcomes-Based Education (OBE) theory [10]. In the field of engineering courses, Zhang Yutao et al. proposed specific measures for civil engineering testing courses, including reconstructing the curriculum system oriented by job competencies, constructing an integrated teaching model of courses, competitions, and certificates, and deepening the school-enterprise dual education mechanism [11–12]. Xu Jiansu explored the "Three Uses," "Four Integrations," and "Five Progressions" classroom revolution pathway in law courses [11]. Yi Wenjuan validated the feasibility of AI-empowered JCCC-integrated curriculum reform in the Corporate Finance course [13]. However, research on systematically integrating AI technologies with JCCC remains relatively scarce. Existing studies tend to focus either on AI technology applications or on JCCC integration, lacking systematic model construction that deeply integrates both throughout the entire teaching process.

2.4. Gaps in existing research and the entry point of this study

In summary, existing research has three major limitations [1–7, 10–13]: first, research on JCCC integration and AI empowerment has largely progressed along separate tracks, lacking a systematic framework for deep integration; second, relevant studies on engineering courses rarely design AI technologies as an empowering variable throughout the entire teaching process; and third, existing teaching models are mostly at the level of conceptual advocacy, lacking actionable and replicable practical pathways. This study addresses these gaps by taking courses in the Cost Engineering major as the practical context, exploring a systematic teaching model for AI-empowered JCCC integration.

3. Construction of the "Four-Dimensional Integration and Five-Stage Progression" AI-Empowered teaching model

3.1. Logical starting point of model design

The design of this model follows the basic logic of "industry demand anchoring → AI technology embedding → teaching process reconstruction." First, it starts with the actual job competency requirements of the intelligent construction industry to identify the core competencies that engineering courses should cultivate. Second, it uses domestic AI large language models such as DeepSeek as the technological foundation to achieve intelligent parsing of industry technical documents, precise diagnosis of learning data, and dynamic generation of teaching resources. Finally, it restructures teaching content through the "Four-Dimensional Integration" and optimizes the teaching process through the "Five-Stage Progression," forming a closed-loop system integrating "objectives—content—process—evaluation."

3.2. The "Four-Dimensional Integration": Four-dimensional restructuring of teaching content

The "Four-Dimensional Integration" refers to the organic integration of four dimensions—job requirements, competition standards, certificate criteria, and AI technologies—into the teaching content, achieving its restructuring and upgrading.

First, integration with job requirements. Using the actual workflow of Cost Engineering positions as the organizing thread, real enterprise projects are transformed into course-based teaching cases, allowing students to encounter authentic work tasks in the classroom.

Second, integration with competition standards. The requirements of vocational college skill competitions are transformed into classroom practical training tasks, using competition standards to drive the enhancement of teaching standards.

Third, integration with certificate criteria. The assessment points of vocational skill level certificates are aligned with and embedded into the knowledge modules and skill training sessions of the course.

Fourth, integration with AI technologies. AI tools such as DeepSeek are introduced to achieve empowerment at three levels: at the lesson preparation stage, AI analyzes student learning data to generate personalized teaching needs reports; at the teaching stage, AI parses enterprise technical documents to automatically generate contextualized teaching cases and differentiated exercises; at the evaluation stage, AI integrates multi-source data to generate student learning profiles and competency diagnosis reports.

3.3. The "Five-Stage Progression": Five-stage optimization of the teaching process

The "Five-Stage Progression" refers to the design of the teaching process into five progressive stages: context creation → task-driven learning → application-driven learning → practical drill → outcome presentation, following the cognitive pattern of "action—questioning—thinking—learning—comprehension" of higher vocational students and the professional competency development pattern of "novice—beginner—competent—expert—master."

Stage 1: Context Creation. Teachers use AI-generated or extracted authentic engineering scenarios from the enterprise case library, presented through virtual simulation technology or multimedia means, to stimulate students' learning interest and problem awareness.

Stage 2: Task-Driven Learning. The industrial problems in the context are transformed into specific, actionable learning tasks, with task difficulty following a progressive logic from simple to complex and from singular to comprehensive.

Stage 3: Application-Driven Learning. As students encounter knowledge obstacles during task completion, they learn "on demand"—acquiring knowledge and practicing skills precisely when needed. Teachers monitor students' difficulties in real-time using AI learning analytics tools to provide targeted guidance.

Stage 4: Practical Drill. Students complete comprehensive engineering tasks in groups within CAD or BIM software environments, experiencing the entire process from drawing reading and modeling to quantity calculation. Enterprise mentors can participate in guidance and commentary through online platforms.

Stage 5: Outcome Presentation. Each group presents their task outcomes, receiving multi-party evaluations from teachers, peers, and enterprise mentors. The AI system concurrently generates process-based learning data reports to provide data support for student competency profiling.

3.4. Embedding of AI tools throughout the entire teaching process

In this model, AI embedding is not a scattered "decoration" but a systematic empowerment running through the entire "teaching-learning-evaluation" process. At the instructional design stage, DeepSeek analyzes students' prior course performance and learning behavior data to generate class learning profiles and tiered teaching objectives. At the resource development stage, AI parses enterprise technical documents and engineering drawings, automatically extracting key knowledge points to generate contextualized teaching cases, differentiated exercises, and micro-lecture scripts. At the classroom teaching stage, AI collects students' classroom interaction data, practical operation data, and in-class quiz data in real time, dynamically generating learning heat maps to assist teachers in adjusting teaching strategies. At the after-class tutoring stage, AI pushes personalized learning resources and targeted exercises based on each student's weak knowledge points. At the evaluation feedback stage, AI integrates process-based data (classroom performance, practical training records), outcome-based data (work quality, test scores), and external data (enterprise evaluations, certificate acquisition) to generate multidimensional competency radar charts.

4. Practical pathways and implementation strategies

4.1. Restructuring of course content

Course content is restructured according to the "Four-Dimensional Integration" philosophy. The restructured course content is divided into three modules: the foundational module covers drafting standards and projection principles, aligned with the basic knowledge points of professional certificates; the advanced module uses typical engineering cases as carriers, covering the reading and drafting of construction drawings, aligned with core job competencies and competition requirements; the comprehensive module relies on real engineering projects, covering the entire process from drawing reading to BIM modeling, incorporating cutting-edge AI-assisted design technologies.

4.2. Teaching implementation process

The "Five-Stage Progression" process is strictly followed in teaching implementation. Taking the teaching unit of "reading reinforcement detailing drawings and calculating reinforcement quantities" as an example: at the context creation stage, teachers use AI to generate construction drawings of actual projects and play on-site construction videos to help students establish spatial concepts; at the task-driven stage, teachers assign the learning task of "reading the reinforcement detailing drawings and calculating reinforcement quantities"; at the application-driven learning stage, when students encounter knowledge obstacles such as detailing rules and structural requirements during the reading and calculation process, teachers provide targeted explanations; at the practical drill stage, students complete the construction drawing drafting and reinforcement quantity calculation in software; at the outcome presentation stage, each group presents their outcomes, receiving joint feedback from teachers and enterprise mentors.

4.3. Construction of diversified evaluation

This model constructs a three-dimensional evaluation system encompassing "process-oriented evaluation + outcome-oriented evaluation + value-added evaluation." Process-oriented evaluation relies on the AI platform to record students' classroom participation, practical operation procedures, and group collaboration performance. Outcome-oriented evaluation includes work quality, test scores, and certificate acquisition status. Value-added evaluation focuses on individual students' progress across the dimensions of knowledge, skills, and competencies, embodying the philosophy of "assessing progress rather than absolute performance." Evaluation data from all three dimensions are integrated through the AI system to generate individualized competency development radar charts and personalized learning recommendations.

5. Practical outcomes and reflection

5.1. Preliminary practical outcomes

This model was piloted in the Cost Engineering major at a higher vocational institution in Chongqing. After one semester of teaching practice, the experimental class demonstrated significant improvements in the following areas: learning initiative was notably enhanced, with substantial increases in both pre-class preparation completion rates and classroom interaction participation rates; skill mastery was more solid, with experimental class average scores significantly higher than the control class on the final practical assessment; certificate pass rates improved markedly, with the experimental class's first-attempt pass rate for vocational skill level certificate examinations significantly exceeding that of the control class; and job adaptability was strengthened, with enterprise mentors reporting high satisfaction levels with experimental class students on core competency indicators.

5.2. Problems and reflection

Several issues emerged during the practical implementation. First, varying levels of teacher digital literacy—some teachers were not sufficiently proficient in operating AI tools, limiting the full realization of AI empowerment effects. Second, quality control of AI-generated content—AI-generated teaching cases occasionally lacked precision in professional details, requiring manual review and correction by subject matter experts. Third, barriers to school-enterprise data flow—obtaining and de-identifying enterprise technical documents still presents obstacles, constraining the frequency of updating industry cases.

These issues need to be gradually addressed in subsequent research through enhanced teacher training, establishment of AI content review mechanisms, and deepening of school-enterprise data cooperation.

6. Conclusion and prospects

This study takes courses in the Cost Engineering major as the practical context and constructs a "Four-Dimensional Integration and Five-Stage Progression" teaching model for AI-empowered JCCC integration. The theoretical contributions of this model are twofold: it organically integrates constructivist learning theory and industry-education integration theory, forming a "problem-driven → AI-enhanced transformation → competency feedback to industry" bidirectional empowerment logical framework; and it elevates AI technologies from "teaching aids" to "structural variables of the teaching model," achieving systematic AI embedding throughout the entire teaching process. The practical value of this model lies in: restructuring teaching content through the "Four-Dimensional Integration," optimizing the teaching process through the "Five-Stage Progression," and achieving precise instruction and personalized learning through AI empowerment, providing an actionable and replicable practical paradigm for the intelligent teaching reform of higher vocational engineering courses.

Looking ahead, future research will deepen in the following directions: first, expanding the scope of practice to validate the model's effectiveness across more engineering courses; second, deepening the level of AI application by exploring more advanced applications such as intelligent Q&A, automated item generation, and AI-assisted grading based on large language models; third, refining the evaluation system by further specifying AI-driven competency diagnosis models and personalized learning pathway recommendation algorithms; fourth, establishing school-enterprise data sharing mechanisms to break down data barriers between industry and education, enabling dynamic updates of teaching content and co-evolution of the industry-education ecosystem.

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