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# Construction of the Curriculum System for the Engineering Cost Major from the Collaborative Perspective of Industry-Education Integration and Digital-Intelligence Integration

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**Abstract:** Against the backdrop of digital-intelligence technologies profoundly reshaping the construction industry and industry-education integration becoming a core direction for vocational education reform, the traditional curriculum system of the engineering cost major in higher vocational colleges faces the dual dilemma of "technical disconnection from the industry and teaching detachment from practice." This paper takes the engineering cost major at Chongqing Energy Vocational College as the research subject, systematically analyzing the background and significance of curriculum system construction from the "dual-collaboration" perspective of industry-education integration and digital-intelligence integration. It clarifies four construction principles: "symbiotic integration of digital-intelligence and major, precise alignment with enterprise needs, integration of courses, positions, competitions, and certificates, and dynamic optimization." Subsequently, it proposes three construction paths: a modular curriculum framework design of "digital-intelligence foundation–professional core–practical innovation–ideological and political integration," collaborative development of curriculum resources by schools and enterprises, and an integrated assessment and evaluation system of "courses, positions, competitions, and certificates." The study aims to provide practical references for cultivating compound technical and skilled talents in the engineering cost major of higher vocational colleges to meet the demands of the digital-intelligence era, thereby facilitating the digital transformation and upgrading of the construction industry.

**Keywords:** Industry-education integration; Digital-intelligence integration; Curriculum system; Courses, positions, competitions, and certificates

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## 1. Construction background and significance

### 1.1. Industry digital-intelligence transformation drives curriculum system upgrades

The "14th Five-Year Plan for the Development of Intelligent Manufacturing" explicitly proposes to "promote the integration of the manufacturing industry with digital and intelligent technologies and cultivate interdisciplinary talents that meet market demands in an all-round way." As a pillar industry of the national economy, the construction industry is accelerating its transition towards digitalization and intelligence. Technologies such as Building Information Modeling (BIM), big data analytics, and intelligent cost-estimating platforms have been deeply integrated into the entire process of engineering cost management, from cost estimation in the early stages of projects, dynamic measurement during the construction phase, to settlement audits after project completion. All these aspects impose new requirements on practitioners' ability to apply digital and intelligent tools and their cross-scenario practical capabilities [1]. However, the current curriculum system for the engineering cost management major in higher vocational education exhibits significant lag: On the one hand, traditional courses still focus on rated pricing and manual calculation, providing insufficient coverage of digital and intelligent content such as BIM modeling for quantity calculation and operation of intelligent cost-estimating software. On the other hand, while some institutions have introduced digital and intelligent courses, these are mostly standalone modules that are not deeply integrated with the core professional knowledge, resulting in students who "understand technology but cannot apply it, and know theory but lack practice." There is a significant mismatch between talent cultivation and industry demands.

## 1.2. Industry-education integration: A key pathway to address practical teaching challenges

As a core pathway for vocational education to align with industrial demands [2], industry-education integration plays an irreplaceable role in cultivating talents for the engineering cost management major. However, based on the practices of Chongqing Energy Vocational College and similar institutions in the industry, current school-enterprise cooperation mostly remains at a "superficial level": Cooperation primarily involves student internships, while the real project needs of enterprises and the latest industry standards have not been effectively translated into teaching resources. There are few cases of jointly developed courses and co-constructed practical training scenarios between schools and enterprises. The gap between classroom teaching and actual job requirements is prominent. The quantity calculation methods and cost-estimating rules that students learn in school differ from the "BIM collaborative cost estimation" and "big data cost control" models actually applied by enterprises. As a result, graduates require extensive secondary training by enterprises before they can become competent in their roles, which not only increases the training costs for enterprises but also reduces students' employability.

## 1.3. The core value of constructing a "dual integration" curriculum system

Reconstructing the curriculum system of the engineering cost major from the perspective of the "dual synergy" of industry-education integration and digital-intelligence integration holds three core values: Firstly, it enhances the precision of talent cultivation. By integrating enterprise needs into curriculum design, it ensures that teaching content closely aligns with job competency requirements. Secondly, it strengthens digital-intelligence application capabilities. By treating digital-intelligence technologies as a vehicle for enhancing professional competencies, rather than as standalone add-ons, it cultivates students' ability to solve practical engineering problems using digital-intelligence tools, meeting the industry's demand for digital-intelligence transformation. Thirdly, it supports the high-quality development of the industry. Through curriculum system reform, it delivers high-caliber technical and skilled talent with digital-intelligence thinking and practical abilities to the construction industry, driving the transformation of the engineering cost field from "traditional manual operations" to "intelligent collaborative management" and fulfilling the positioning of higher vocational colleges in serving regional economic development [3].

## 2. Construction principles

### 2.1. Principle of "symbiotic integration" of digital-intelligence technologies and professional knowledge

Avoid simply superimposing digital-intelligence technologies onto traditional curricula. Instead, based on the core competencies of the engineering cost major (engineering measurement, cost calculation, cost control, settlement auditing), digital-intelligence technologies should serve as "tools" and "supports" for enhancing competencies. For example, in the course "Engineering Measurement and Pricing," rather than offering a standalone "BIM Technology Course," a "commercial complex project" is used as a teaching vehicle. This approach simultaneously explains traditional fixed-amount measurement rules and BIM modeling measurement processes, guiding students to understand the role of digital-intelligence technologies in improving measurement efficiency and accuracy by comparing the results of the two methods. This achieves the teaching objective of "empowering professional decision-making with digital-intelligence technologies" and ensures deep integration and synergistic collaboration between digital-intelligence technologies and professional knowledge.

### 2.2. Principle of "precise alignment" between enterprise needs and curriculum content

Leveraging the established school-enterprise cooperation mechanism at Chongqing Energy Vocational College, a "School-Enterprise Curriculum Development Committee" composed of enterprise technical leaders and school professional teachers is formed to establish a closed-loop mechanism of "enterprise needs survey–curriculum content iteration–teaching effectiveness feedback." Regularly conduct research on job requirements. Each year, for emerging positions such as "Digital and Intelligent Cost Engineer" and "BIM Cost Collaboration Specialist," collect specific requirements from enterprises regarding talent capabilities, and adjust course modules accordingly. Transform corporate resources into teaching resources by incorporating anonymized real project drawings and cost cases from enterprises into teaching, and integrating internal training standards of enterprises into course assessments. Establish a feedback channel for requirements, regularly collect capability evaluations of graduates from partner enterprises, and optimize course practical sessions to address issues such as "unskilled application of digital and intelligent tools" and "insufficient practical project experience," ensuring that course content continuously aligns with the actual needs of enterprises.

### 2.3. Principle of integration and practice orientation of "courses, positions, competitions, and certificates"

Centered on "job capability requirements," integrate the four key elements of "course teaching, job practice, skill competitions, and vocational certificates" to construct a practice-oriented curriculum system. First, align courses with positions: design the sequence of course modules by referencing the workflow of cost engineering positions, ensuring that students' learning paths are consistent with job work paths. Second, align practice with competitions: incorporate assessment content from competitions such as "Construction Engineering Quantity Measurement and Pricing Competition" and the "Belt and Road & BRICS Skills Development and Technological Innovation Competition" into course practical sessions, enhancing students' practical capabilities through competition standards. Third, align teaching with certificates: align with the standards of the "1+X" Vocational Skill Level Certificate for Digital Application in Cost Engineering (Intermediate), incorporating certificate assessment content into course teaching. Students obtaining the certificate can have it counted as corresponding course credits, achieving "integration of courses and certificates" and enhancing employability.

### 2.4. Principle of dynamic adjustment and long-term optimization

Considering the rapid iteration of digital and intelligent technologies and the frequent updates to construction industry standards, the curriculum system needs to establish a "dynamic updating mechanism." First, track the development of digital and intelligent technologies, collaborate with digital and intelligent technology service providers, research new technological applications in the industry, and promptly incorporate mature technologies into the curriculum. Second, synchronize with changes in industry standards, adjusting teaching content on pricing rules and quantity calculation methods in the curriculum in response to new norms and requirements issued by the state. Third, we will analyze employment feedback data. By visiting employing entities and collecting information on the career development of graduates, we will identify course content that is out of sync with job requirements, optimize the weighting of course modules, and ensure that the curriculum system consistently meets the needs of industry development and talent cultivation.

## 3. Construction paths

### 3.1. Design of a modular curriculum system framework

Centered around the four modules of "Digital Intelligence Foundations–Professional Core–Practical Innovation–Ideological and Political Integration," we will establish a curriculum system with distinct layers and logical coherence. Each module independently supports the cultivation of specific abilities while also interconnecting to form a comprehensive ability cultivation chain of "digital intelligence + professional skills + practical experience" [4].

#### 3.1.1. Digital intelligence foundations module: Laying a solid technical foundation

Focusing on "cultivating digital intelligence thinking" and "tool operational capabilities," this module provides technical support for subsequent professional studies. For example, the course "Introduction to BIM and 3D Modeling" is jointly taught by dual instructors from both schools and enterprises (school professional teachers + BIM technology engineers). The content covers operations of BIM modeling software such as Revit, application scenarios of BIM in project costing (e.g., clash detection, quantity calculation), and practical training using real enterprise project models (e.g., BIM models of residential projects) to ensure students master basic BIM operational skills.

#### 3.1.2. Professional core module: Achieving deep integration of "digital intelligence + professional skills"

We will conduct a "digital intelligence transformation" and "industry-education integration upgrade" of traditional professional core courses to ensure that the teaching content covers both core professional knowledge and incorporates digital intelligence technologies and enterprise practical needs. For example, in the course "Construction Project Quantification and Pricing," using a "commercial complex project" as the teaching vehicle, we will teach both "traditional manual quantification" and "BIM modeling quantification" simultaneously: first explaining the rules for normative quantification, then guiding students to establish project models using BIM software and set calculation parameters, and comparing the results of the two methods. The course practical training uses real enterprise project drawings, requiring students to complete the full process from modeling to generating a bill of quantities, with grading participation from enterprise mentors.

### 3.1.3. Practical innovation module: Establishing a three-tier practical chain of "on-campus–enterprise–competition"

This module aims to "enhance practical capabilities and foster innovative thinking," conducting practical teaching across three levels to achieve a progressive increase in abilities "from simulated training to real-world projects":

(1) On-campus training: Virtual simulation + digital training: Leveraging the jointly established "Digital Cost Estimation Training Center" by the school and enterprises, two types of training are conducted: First, virtual simulation training, which utilizes a virtual simulation platform to simulate complex engineering scenarios such as cost control for super high-rise projects and quantity calculation for irregular structures. Through operating virtual models, students master the application of digital and intelligent tools in special scenarios. Second, digital collaborative training, using the "Industrial Park Project" as a carrier, students are grouped to play roles such as "cost estimator," "auditor," and "project manager," utilizing a BIM collaborative platform to complete the entire process of cost documentation preparation, review, and feedback, thereby cultivating teamwork abilities.

(2) Enterprise practice: Real projects + dual mentorship: Enterprise practice is conducted in two stages: First, short-term cognitive internships, where students are organized to visit partner enterprises to understand their digital and intelligent cost estimation processes. Second, long-term on-the-job internships, where students join enterprise cost departments to participate in real-world projects. Guided jointly by enterprise mentors and school teachers, students complete a closed loop of "job tasks–internship logs–achievement reports," with internship assessment scores jointly determined by mentors from both the school and the enterprise.

(3) Project innovation: Research projects + skills competitions: Guided jointly by mentors from the school and enterprises, research is conducted using enterprise project data and digital and intelligent tools. Outstanding research project results are recommended for industry exchange. Simultaneously, by aligning with relevant competitions, competition training teams are formed to enhance students' digital and intelligent application and practical innovation capabilities.

### 3.1.4. Ideological and political integration module: achieving synergy between "value guidance + professional training"

Integrate ideological and political elements throughout the entire course teaching process to avoid the separation of "ideological and political education from professional training," with a focus on excavating three types of ideological and political elements:

Cultivation of industry values: In the course of "Application of Digital Cost Estimation Technology," the development trajectory of China's independently developed cost estimation software (such as Glodon), from "following the pack" to "taking the lead," is explained to cultivate students' confidence in technology and a sense of industrial responsibility. In the course of "Cost Estimation Control and Management," case studies such as "cost estimation data fraud leading to engineering quality issues" are used to emphasize the professional ethics of "integrity in cost estimation, responsibility first."

Shaping of craftsmanship spirit: In practical courses, "striving for perfection" is set as the standard—students are required to achieve BIM modeling accuracy with an error margin of no more than 0.5% and an accuracy rate of engineering quantity calculation of no less than 98%, cultivating a rigorous and meticulous work attitude through strict practical training assessments. Enterprise "master craftsmen" are invited to campus to share their professional experiences of "a decade of deep involvement in the cost estimation field," transmitting the craftsmanship spirit of “focus, perseverance, and innovation.”

## 3.2. Collaborative development of curriculum resources by schools and enterprises

Curriculum resources serve as the core support for the implementation of the “dual integration” curriculum system. Leveraging the existing school-enterprise cooperation resources of Chongqing Energy Vocational College, teaching resources that are “aligned with industry realities and integrated with digital intelligence technologies” are collaboratively developed from the following three aspects:

### 3.2.1. Development of dual-source textbooks and loose-leaf lecture notes

In collaboration with partner enterprises and digital intelligence technology service providers, two types of textbooks are developed: First, school-enterprise dual-source textbooks, which supplement chapters on the application of digital intelligence technologies based on existing textbooks and incorporate real project drawings and cost estimation documents from enterprises to ensure that the textbook content is “derived from practice and used in practice.” Second, loose-leaf lecture notes are compiled to address the rapid iteration of digital intelligence technologies and frequent updates in industry standards. The content of these lecture notes is updated every semester according to changes in technology and standards to maintain the timeliness of the teaching materials.

### 3.2.2. Construction of a digital teaching resource library

A “Digital Teaching Resource Library for Engineering Cost Estimation” is established, encompassing four types of resources: First, a BIM Model Library, which collects BIM models of various types of projects, such as residential, commercial, and municipal projects, provided by partner enterprises, and annotates key quantity calculation nodes and pricing points for students’ self-directed learning. Second is the virtual simulation project library, where students can engage in practical training anytime through an online platform. The platform automatically records the operation process and results, generating a capability assessment report. Third is the enterprise case library, which compiles real-world enterprise cost estimation cases and analyzes the problems and solutions within them. Fourth is the online course resources, which support students in previewing and reviewing materials online, enabling a “blended online and offline teaching” approach.

### 3.2.3. Construction of a “dual-qualified” teaching staff

The “Dual Integration” curriculum system requires the support of “dual-qualified” teachers. The teaching staff is cultivated through three approaches: First is enterprise practice training, where professional teachers are arranged to work in the cost estimation departments of enterprises annually, participating in real projects and learning about the enterprise’s digital and intelligent cost estimation processes and technological applications. Second is digital and intelligent skills training, where teachers are organized to participate in training to enhance their digital and intelligent teaching capabilities. Third is mutual employment of teachers between schools and enterprises, where enterprise cost estimation directors and technical leaders are hired as part-time teachers, while outstanding teachers from the school are selected to conduct employee training at enterprises (such as training on the operation of digital and intelligent cost estimation tools), achieving the sharing of teaching resources between schools and enterprises [5].

### 3.3. Construction of an integrated “course-position-competition-certificate” assessment and evaluation system

The traditional “final written exam” approach is inadequate for assessing students’ digital and intelligent application capabilities and practical abilities. Based on the “dual integration” concept, an integrated “course-position-competition-certificate” assessment and evaluation system is constructed, comprehensively evaluating students’ abilities from four dimensions: “knowledge, skills, practice, and certificates.”

#### 3.3.1. Assessment content: Aligning with job requirements, competition standards, and certificate criteria

The core competencies required for the engineering cost estimation job serve as the focus of the assessment, incorporating competition requirements and certificate criteria: First is knowledge assessment, which evaluates students’ mastery of professional theories and the fundamentals of digital and intelligent technologies through written exams and online tests. Second is skills assessment, which examines students’ abilities to apply digital and intelligent tools through practical operation tests. Third is practical assessment, which requires students to complete a full-process task of “cost estimation document preparation-cost analysis-settlement report” based on real enterprise projects. The assessment indicators include “accuracy of results, standardization of processes, and rationality of digital and intelligent tool applications,” and are jointly graded by teachers from both schools and enterprises. Fourthly, competition bonus points: students who participate in competitions and win awards can convert these achievements into corresponding course credits, encouraging them to promote learning through competitions [6].

#### 3.3.2. Assessment methods: Combining process-based assessment with summative assessment

Breaking away from the model of “one exam determining grades,” we adopt a method that combines “process-based assessment (accounting for 60%) + summative assessment (accounting for 40%)”: Firstly, process-based assessment dynamically records students’ learning progress through classroom practical training, enterprise internships, project assignments, and other activities. Secondly, summative assessment focuses on “comprehensive project practical exercises,” requiring students to complete BIM modeling, quantity calculation, intelligent pricing, and cost analysis for an “office building project” within a specified timeframe, and submit complete cost documentation. A review panel composed of instructors from both schools and enterprises evaluates the students based on three dimensions: “quality of outcomes, technological application, and problem-solving.”

#### 3.3.3. Assessment tools: Digital platforms enable precise assessment

Leveraging the school’s teaching platform and digital tools, we achieve “digitization and precision” in assessment and evaluation: Firstly, learning data collection involves recording students’ online course learning duration, practical training operation steps, and assignment submission status through the teaching platform, automatically generating a “learning behavior profile.” Secondly, skill level analysis utilizes professional tools such as Glodon BIM review software to automatically detect the accuracy of students’ outcomes in practical assessments like BIM modeling and intelligent pricing, generating reports on skill gaps. Thirdly, competence attainment assessment establishes a “competence attainment matrix” [7] based on the “1+X” certificate standards and enterprise job competence requirements. By analyzing data from process-based and summative assessments, we evaluate students’ attainment in dimensions such as “digital intelligence application, professional knowledge, and practical ability,” providing a basis for personalized teaching and career development advice.

## 4. Conclusion

Our school's Construction Cost Engineering program has undertaken a practical reconstruction of its curriculum system, driven by the dual engines of "integration of industry and education" and "integration of digital intelligence." We have established a modular curriculum framework that encompasses "Digital Intelligence Fundamentals–Professional Core Competencies–Practical Innovation–Integration of Ideological and Political Education." Through collaboration between schools and enterprises, we have jointly developed project-based teaching resources, integrating real-world work scenarios and case studies into daily instruction. Concurrently, we have instituted a comprehensive evaluation system that integrates "curriculum, positions, competitions, and certifications," moving away from a sole focus on grades and instead evaluating students holistically based on their job skills, competition performance, and acquisition of professional certifications. This series of teaching practices aims to effectively enhance students' digital intelligence application capabilities and comprehensive professional qualities, providing robust talent support for the digital transformation of the construction industry and offering practical examples that can be referenced for teaching reforms in similar majors.

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## Disclosure statement

The author declares no conflict of interest.

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