

# Model Construction and Path Analysis of "Engineering Project Management" Digital Textbook Construction Empowered by AIGC

Wei Zhang, Qin Li\*

Anhui University of Finance and Economics, Bengbu, Anhui 233000, China

\* Corresponding author: Qin Li

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**Abstract:** Against the backdrop of the deepening strategy of educational digitization, AIGC (Artificial Intelligence Generated Content) is experiencing explosive development. Meanwhile, the shortcomings of traditional Engineering Project Management textbooks—specifically regarding dynamic content updates, interactive learning experiences, and practical teaching segments—are becoming increasingly prominent. From the perspective of AIGC-empowered teaching, this article deeply analyzes the realistic dilemmas of traditional textbooks, such as lagging knowledge updates, singular teaching scenarios, and the disconnection between theory and practice. We propose a theoretical model for digital textbook construction centered on "Content Generation - Scene Simulation - Intelligent Evaluation." This model utilizes AIGC technology to dynamically reconstruct textbook content and achieve cross-modal presentation, generates highly simulated virtual project scenarios to strengthen immersive learning experiences, and establishes an intelligent evaluation and personalized guidance system. This study aims to provide a feasible practical reference for the development of digital textbooks.

**Keywords:** AIGC, Digital Textbook, Engineering Project Management, Educational Digitization, Intelligent Evaluation.

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## 1. Introduction

Engineering Project Management is a core course for majors in Engineering Management and Engineering Cost. It integrates management science, engineering technology, economic law, and information technology, emphasizing the combination of theory and practice. The course aims to cultivate students' theoretical knowledge in project planning, scope management, schedule control, cost management, quality management, safety management, risk management, and contract management. Furthermore, it focuses on developing students' abilities to solve actual project problems and coordinate with multiple stakeholders, such as handling schedule delays caused by weather conditions or preparing tender documents.

Currently, most existing textbooks follow the mode of "paper textbooks accompanied by digital resources," which presents several significant problems [1, 2]. First, knowledge updates lag behind, making it difficult to keep pace with the iteration of industry practices, policies, regulations, and software tools. Frontier content such as EPC (Engineering, Procurement, and Construction), PPP (Public-Private Partnership), full-lifecycle BIM applications, and smart construction sites driven by artificial intelligence are often not included in a timely manner [3]. Second, teaching cases are static and abstract, lacking the presentation of the dynamic evolution of projects. This makes it difficult for students to intuitively understand the key points of project management and decision-making logic. Third, practical links are weak; due to limited conditions, students lack a "full-process" management experience of real projects, affecting the transformation of theoretical knowledge into practical operational ability. Fourth, evaluation methods are singular, focusing primarily on theoretical assessment while lacking process-based assessment of decision-making, coordination, and risk-response capabilities, making it difficult to

comprehensively reflect students' overall literacy.

The rapid development of Generative Artificial Intelligence (AIGC) has triggered multidisciplinary discussions on its opportunities and implications for research and practice [4]. This technology provides new ideas for solving the aforementioned teaching dilemmas [5]. Large language models (LLMs) have shown significant potential in educational settings, particularly in offering personalized feedback and fostering critical thinking [6]. Its advantages in content generation, context construction, and natural language interaction make it an effective teaching tool. AIGC can automatically generate engineering cases, exercises, and frontier knowledge, and build highly simulated virtual project environments to facilitate "learning by doing." For example, by simulating scenarios such as construction project schedule optimization or commercial residential development cost control, students can hone their professional skills in an immersive experience. Therefore, studying the practical path of AIGC-empowered Engineering Project Management digital textbooks has important practical significance for improving course teaching quality and cultivating engineering talents in the digital age [7–10].

## 2. The Theoretical Model

Based on the technical characteristics of AIGC and the requirements of the Engineering Project Management course, we propose a "Three-Layer Empowerment, Closed-Loop Iteration" digital textbook theoretical model. This model is learner-centered, achieving intelligent processes for content supply, practical experience, and evaluation guidance to form a teaching loop.

The first layer is the Content Layer, which serves as an AIGC-driven dynamic knowledge base. Its core composition uses the engineering project management knowledge graph as the underlying architecture, integrating four major modules: theoretical knowledge, case resources, exercise training, and

frontier dynamics. The theoretical knowledge module covers core knowledge points across all stages of the project lifecycle; the case resource module contains real cases of different project types such as building construction, municipal engineering, hydraulic engineering, and rail transit; the exercise training module designs special exercises and comprehensive practical tasks for each knowledge point; and the frontier dynamics module updates policies, regulations, technological innovations, and industry trends in real time. We utilize Large Language Models (LLMs) to generate and update text content such as project management theories, typical cases, and specialized exercises—for instance, generating a risk register for an urban expressway project or a cost estimation report for a commercial complex EPC project. Simultaneously, multi-modal generation models are used to convert key knowledge points into visual resources like construction drawings, progress animations, 3D engineering models, and virtual simulation videos. Examples include transforming flow construction organization into dynamic animations or turning BIM collision detection applications into 3D simulation videos. Through real-time data interfaces, the system captures the latest information on industry policies, standard specifications, and engineering cases to achieve dynamic iteration of the knowledge base.

The second layer is the Interaction Layer, representing an AIGC-constructed virtual project environment. Its core is a virtual simulation platform covering the full lifecycle of engineering projects, including initiation, planning and design, construction implementation, completion acceptance, and operation and maintenance. It includes three major systems: role interaction, scene decision-making, and task execution. The role interaction system supports students in playing different job roles and interacting with AI-generated virtual team members such as construction workers, supervision engineers, owner representatives, and suppliers. The scene decision-making system simulates problems and challenges in different engineering scenarios. The task execution system provides the tools and process support needed to complete project management tasks. Based on AIGC, highly simulated engineering scenarios are generated—such as residential building construction, bridge construction, municipal road renovation, and subway project maintenance—recreating details like site layout, machinery operation, personnel interaction, and document flow to match the real engineering environment. Students can participate in interactions within these scenarios through natural language dialogue, task operations, and decision choices. For example, in a schedule deviation handling scenario, students need to adjust the network plan, coordinate resource allocation, and communicate schedule changes with the owner based on actual construction data. The system provides real-time feedback on the effects of decisions, thereby strengthening the practical experience.

The third layer is the Evaluation Layer, which is the AIGC-supported intelligent evaluation and guidance system. Its core composition includes four modules: process data acquisition, ability assessment models, personalized guidance, and feedback optimization. The process data acquisition module records students' behavioral data in virtual projects in real time. The ability assessment model conducts multi-dimensional evaluations based on the core competency index system of engineering project management. The personalized guidance module pushes targeted resources and tasks based on evaluation results. The feedback optimization module

collects user feedback to continuously iterate system functions. Through sensors and interaction logs, the system collects full-process data of students in virtual projects. The multi-dimensional evaluation is based on an index system where primary indicators include professional knowledge mastery, practical operation ability, decision analysis ability, communication and coordination ability, risk response ability, and teamwork ability, with secondary indicators detailed into specific evaluation points. AIGC is used to generate personalized learning reports that identify capability gaps. Based on the assessment results, the system automatically pushes targeted learning resources, tutorial videos, and reinforcement tasks, forming a "Learning-Practice-Evaluation-Improvement" closed-loop iteration.

### 3. Construction Paths

#### 3.1. Dynamic Content Reconstruction

The core of content dynamic reconstruction is to promote the transformation of traditional static text into a living knowledge base, which can be advanced from three aspects.

First is the construction of a domain knowledge graph. Based on the Engineering Project Management curriculum standards and core knowledge points, we analyze the knowledge associations of core modules such as project planning, scope management, schedule management, cost management, quality management, safety management, risk management, and contract management to build a structured knowledge graph. The knowledge graph must include multi-layered information such as knowledge points, association rules, application scenarios, and case resources. For example, the "Critical Path Method" knowledge point needs to be associated with application scenarios like network diagram drawing, schedule deviation analysis, and resource optimization allocation, as well as corresponding building and municipal engineering cases, providing a clear logical framework for AIGC content generation.

Second is the dynamic generation and updating of content. We utilize AIGC technology to achieve automated generation and dynamic updates of textbook content. On one hand, based on the knowledge graph, basic content such as theoretical chapters, case analyses, and exercise training is generated. For instance, the system can generate detailed explanations of engineering project bidding processes or key points of construction phase cost control, and design case analysis questions like schedule optimization for an office building project or risk assessment for a bridge project, ensuring the integrity and logic of the knowledge system. On the other hand, by interfacing with industry databases, policy release platforms, and engineering case libraries, the system captures the latest policies and regulations in real time—such as updates to the standard text of construction contracts, technical standards like BIM application specifications, and management practices of large-scale infrastructure projects—to automatically update relevant textbook content. For example, the latest requirements of green construction evaluation standards can be integrated into the quality management chapter, and application cases of smart construction site management systems can be added to the safety management module, effectively solving the problem of knowledge lag.

Finally, there is cross-modal content presentation. Addressing the abstract theories and complex engineering processes in Engineering Project Management, AIGC is used

to achieve cross-modal content conversion. For example, double-entry network diagrams and single-entry network diagrams in network planning technology can be converted into dynamic animations to visually demonstrate work logic and schedule optimization processes; students can drag nodes to adjust work duration and observe changes in the critical path. Cost estimation models can be transformed into interactive calculation tools where students input different parameters like material prices, labor costs, and construction techniques to simulate cost changes and understand the impact of various factors on total cost. Construction organization designs can be converted into 3D construction simulation videos to clearly present construction processes, resource allocation schemes, and site layout planning. Contract clauses can be turned into interactive cases where students simulate contract execution effects and potential risks by selecting different clause combinations.

### 3.2. Immersive Scenario Simulation

The key to scenario immersion simulation is to push teaching from planar explanation towards virtual practice implementation, mainly including three steps.

First is full-lifecycle scenario design. Centering on the engineering project lifecycle, we design virtual practice scenarios covering different stages and types. In the project planning stage, scenarios for feasibility studies and scheme comparison require students to analyze technical feasibility and economic rationality to select the optimal construction scheme. In the construction preparation stage, scenarios for construction organization design and resource allocation require students to formulate construction schedules, configure manpower and machinery, and plan the construction site. In the construction implementation stage, scenarios for schedule control, cost optimization, quality and safety control, and risk disposal require students to handle issues like material supply delays, construction quality defects, and safety hazards. In the completion acceptance stage, scenarios for data organization and acceptance processes require students to compile acceptance reports, handle acceptance objections, and complete final accounts. Each scenario must clarify practical goals, role divisions, task flows, and evaluation standards to ensure orderly practical teaching.

Second is high-fidelity scenario generation and interaction. Leveraging AIGC's capabilities in scenario generation and role simulation, we construct highly realistic engineering environments and interaction logic. Scenarios should replicate details of site layout, machinery operation, personnel interaction, and document flow. For instance, construction scenarios should reproduce tower crane operations, steel reinforcement binding, and concrete pouring processes; bidding scenarios should simulate bid preparation, bid opening and evaluation, and contract negotiation processes. Role design should cover diverse subjects such as project managers, technical directors, construction workers, supervision engineers, owner representatives, and suppliers. Each role possesses unique behavioral logic and communication styles; for example, a supervision engineer will strictly issue rectification opinions based on norms, while an owner representative focuses more on project progress and investment control. Students participate in interactions through natural language dialogue, task operations, and decision choices. The system adjusts the direction of scenario evolution in real time based on student behavior. For example,

if a student fails to address a construction quality issue in time, the scenario will trigger the supervision engineer to issue a stop-work notice, leading to schedule delays and increased costs, allowing students to intuitively feel the consequences of their decisions.

Third is the development of special skill training modules. Targeting core curriculum skill points, special training modules are developed. For example, the schedule management module can design training for network diagram drawing, critical path identification, and schedule deviation analysis and adjustment, where students must adjust work duration and logical relationships based on actual project data to ensure on-time completion. The cost management module can design training for bill of quantities preparation, cost estimation, and cost control and optimization, requiring students to compile bills of quantities based on drawings and market prices, conduct cost analysis, and propose optimization schemes. The risk management module can design training for risk identification, assessment, and response plan formulation, where students identify potential risks in a bridge project, assess risk levels using qualitative and quantitative methods, and formulate strategies for risk avoidance, transfer, or mitigation. The contract management module can design training for contract clause interpretation, claim processing, and dispute mediation, requiring students to analyze breach of contract clauses and handle claims submitted by the construction party. Each module is equipped with intelligent guidance and feedback functions to help students reinforce core skills.

### 3.3. Intelligent Evaluation & Guidance

The core of intelligent evaluation and guidance is to achieve a transformation from result assessment to process empowerment, which can be advanced through three steps.

The first step is to construct a core capability evaluation index system. Combining the goals of the Engineering Project Management course with industry position requirements, we build a multi-dimensional capability evaluation index system. Primary indicators include professional knowledge mastery, practical operation ability, decision analysis ability, communication and coordination ability, risk response ability, and teamwork ability. Secondary indicators refine these into specific evaluation points; for example, professional knowledge mastery includes understanding core concepts, accuracy of method application, and familiarity with policy standards; practical operation ability includes construction organization design preparation, schedule optimization, and cost estimation accuracy; decision analysis ability includes problem identification accuracy, scheme feasibility, and decision efficiency; communication and coordination ability includes expression clarity, negotiation skills, and stakeholder relationship maintenance; risk response ability includes comprehensiveness of risk identification, scientific nature of assessment, and effectiveness of response plans; teamwork ability includes rationality of role division, tacit cooperation, and task completion efficiency.

The second step is process data acquisition and analysis. Through the virtual project platform, the system collects students' learning behavior data throughout the process, including theoretical learning duration, case analysis results, scenario decision records, task completion efficiency, communication interaction content, and error distribution. For example, it records the number and effect of network plan adjustments in the schedule management scenario, the

deviation rate of cost estimates in the cost management module, and the number of identified risks and rationality of response plans in the risk disposal scenario. Using AIGC's data analysis capabilities, the system conducts deep mining of process data to identify students' learning habits, ability strengths, and weaknesses, generating personalized capability portraits. For instance, if a student has solid professional knowledge but insufficient risk response ability, the capability portrait will clearly mark this shortcoming and analyze potential causes, such as incomplete risk identification or lack of feasibility in response plans.

The third step is intelligent evaluation and personalized guidance. Based on the capability evaluation index system and process data analysis results, AIGC automatically generates a comprehensive evaluation report, clarifying the student's performance level and direction for improvement in each capability dimension. Simultaneously, based on evaluation results, the system pushes targeted guidance resources. For example, it pushes network planning technology tutorial videos and case exercises to students with weak schedule management abilities; engineering negotiation skill tutorials and simulated negotiation scenarios to students with insufficient communication and coordination abilities; and typical risk case analyses and response plan templates to students lacking risk response abilities. Furthermore, the system can dynamically adjust learning tasks and practice scenario difficulty based on student learning progress and ability improvement. For example, after a student performs excellently in basic scenarios, the system automatically unlocks complex scenarios like large-scale project management with concurrent multiple risks, achieving personalized learning path planning.

### 3.4. Closed-Loop Optimization

To ensure the quality of digital textbooks, it is necessary to establish a closed-loop iteration mechanism of "Technical Development - Teaching Application - Feedback Optimization." Through pilot programs, feedback from teachers and students is collected-such as teachers suggesting process details for a specific construction scenario, or students reflecting on whether the tutorial resources for a certain knowledge point are suitable for learning. AIGC is used to analyze this feedback data to identify problems existing in the textbook. We then periodically update knowledge content, optimize scenario designs, perfect evaluation models, supplement learning resources for knowledge points, and adjust the weights of evaluation indicators, thereby continuously improving the teaching adaptability and application effectiveness of the digital textbook.

## 4. Conclusion

AIGC technology provides a powerful impetus for the digital transformation and intelligent upgrading of Engineering Project Management textbooks. By constructing a "Content - Interaction - Evaluation" three-layer empowerment model and following the construction paths of

content dynamic reconstruction, immersive scene simulation, intelligent evaluation, and closed-loop optimization, we can effectively solve the prominent problems of traditional textbooks, such as lagging knowledge, weak practice, and singular evaluation. This approach creates a new generation of digital textbooks that are current, practical, personalized, and adaptive, providing a new teaching mode and practical carrier for the cultivation of engineering management professionals, and assisting in cultivating more composite engineering management talents adapted to the needs of the digital age.

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