

Reform and Practice Research on the Project-Based Teaching Method of Civil Engineering Construction

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Abstract: With the continuous development of civil engineering construction technology, course teaching faces challenges such as complex knowledge systems, high skill requirements, and diverse practical components. Project-Based Learning (PBL), as a teaching model centered on task-driven and competency development, provides a new instructional pathway for civil engineering construction courses. Guided by constructivist learning theory, this study explores the theoretical foundations of PBL in civil engineering construction courses, its course adaptability, and its competency-oriented characteristics, with a focus on strategies for hierarchical teaching objectives and project task design, structured and modular reconstruction of teaching content, and the construction of a learning assessment system. At the same time, by integrating teaching resource optimization, information technology support, team collaboration mechanisms, and continuous course improvement pathways, a systematic implementation framework for PBL is established. The study demonstrates that PBL can effectively enhance students' construction skills, systems thinking, engineering decision-making ability, and teamwork, achieving knowledge internalization and skill transfer, and providing theoretical guidance and methodological reference for teaching reform and talent cultivation model innovation in civil engineering construction courses.

Keywords: civil engineering construction; project-based learning; curriculum reform; competency development; teaching optimization

Introduction

As a core course in undergraduate engineering programs, civil engineering construction courses are responsible for cultivating students' construction technical skills, engineering analysis abilities, and comprehensive problem-solving competencies. However, traditional teaching models, which are primarily lecture-based, often result in a disconnect between theory and practice, making it difficult for students to develop a complete engineering cognition system and practical skills. Project-Based Learning (PBL), driven by authentic tasks and multidimensional competency development, provides an effective approach to address these challenges. Under this teaching model, course objectives can be designed hierarchically, project tasks can be implemented in multiple stages, course content can be modularly restructured, and the learning assessment system can integrate both formative and summative evaluation. By incorporating information technology tools and digital resources, students can engage in self-directed exploration and collaborative learning within contexts that combine virtual and hands-on practice, thereby developing systematic construction skills and engineering literacy. The necessity of this study lies in exploring course optimization pathways based on PBL, aiming to innovate the teaching model of civil engineering construction courses and provide scientific theoretical and practical support for cultivating multidisciplinary engineering talents.

1. Theoretical Foundations of Project-Based Learning in Civil Engineering Construction Courses

1.1 Concepts of Project-Based Learning and Educational Theory

Project-Based Learning (PBL), grounded in constructivist learning theory, emphasizes students' active construction of knowledge systems within authentic tasks and contexts. This teaching model, driven by problems and task-oriented objectives, integrates cognitive activities with practical operations throughout the learning process. PBL not only focuses on knowledge transmission but also emphasizes competency development, including the ability to analyze complex engineering problems,

design comprehensive construction plans, and integrate interdisciplinary knowledge. In engineering courses, PBL can overcome the limitations of traditional lecture-based teaching by placing students in contexts that closely resemble real engineering projects, reinforcing the applicability of theoretical knowledge while cultivating systems thinking, engineering decision-making, and technological innovation skills. Educational research indicates that students in PBL environments can develop self-regulated learning strategies, enhance learning motivation and autonomy, and thus provide a solid theoretical foundation for competency-oriented teaching in civil engineering construction courses.

In practical implementation, PBL emphasizes the authenticity and comprehensiveness of tasks. By designing cross-module and interdisciplinary project assignments, it stimulates students' proactive exploration and critical thinking. This approach closely aligns course objectives with the development of students' competencies, achieving the simultaneous growth of knowledge, skills, and engineering literacy. PBL highlights team collaboration and dynamic feedback mechanisms; through group-based construction tasks, students continuously adjust strategies, optimize operational plans, and enhance professional judgment and practical engineering abilities through project reflection. Additionally, this model encourages the use of information technology tools for learning management, such as virtual construction simulations, BIM model analysis, and construction data processing, thereby fostering students' digital engineering skills and innovative mindset in a project-driven environment [1].

1.2 Teaching Characteristics of Civil Engineering Construction Courses

Civil engineering construction courses are highly systematic and practical, with teaching content spanning multiple dimensions, including construction processes, material properties, structural safety, construction organization, and quality control. The courses not only emphasize the integrity of theoretical knowledge but also highlight the practicality and comprehensiveness of construction skills. Students are required to master the full range of skills from construction drawing analysis and process selection to on-site construction management and quality control, while also being able to address unexpected problems on the construction site, achieving efficient integration of theory and practice. The course knowledge exhibits modular characteristics, with theoretical modules, skills modules, and engineering case modules interwoven, providing ample space for task design and competency development in project-based learning. Course objectives focus not only on knowledge transmission but also on the cultivation of students' engineering competencies, including core abilities such as construction technical analysis, construction organization design, and construction safety management.

The characteristics of civil engineering construction courses determine the hierarchical and progressive nature of the teaching content. The courses require students, based on an understanding of construction principles, to transform professional knowledge into operable skills while possessing problem-solving abilities and innovative awareness. During the teaching process, students must integrate knowledge and practice skills through construction simulations, task decomposition, and on-site analysis, forming a complete learning chain from theoretical cognition to engineering application. The systematic and complex nature of the courses provides a natural fit for project-based learning, enabling students to enhance their comprehensive competencies through task-driven and collaborative learning, achieving the transfer from knowledge comprehension to construction capability, and laying the foundation for cultivating multidisciplinary talents who meet the demands of modern engineering.

1.3 Analysis of Course Adaptability for Project-Based Learning

The introduction of Project-Based Learning (PBL) into civil engineering construction courses demonstrates a high degree of adaptability. The course content encompasses the full construction process, multi-stage tasks, and diverse skill requirements, providing abundant materials and authentic contexts for project-driven learning. By breaking down construction tasks into several operable project units, students can apply theoretical knowledge, develop construction skills, and enhance management abilities during task execution, while also cultivating systems analysis and engineering decision-making capabilities. PBL effectively promotes dynamic alignment between course objectives and competency development, enabling students to internalize knowledge, transfer skills, and enhance engineering thinking as they complete construction tasks. This model emphasizes a full closed-loop management from task design to learning feedback, ensuring that students continuously develop professional competencies and innovative thinking throughout project execution [2].

PBL also integrates modern information technology and digital tools, such as BIM models,

construction simulation software, and construction information management systems, providing a learning environment that combines virtual and hands-on practice. Under project-driven conditions, students can simulate construction plan design, construction schedule management, and quality control processes, thereby enhancing digital engineering skills and collaborative abilities. Additionally, this model supports multi-level task challenges and progressive competency development, allowing students to gradually master complex construction skills through completion of unit tasks, achieving a deep integration of knowledge systems and operational abilities, and providing theoretical and methodological support for teaching reform and talent cultivation model innovation in civil engineering construction courses.

2. Design and Optimization Strategies of Project-Based Teaching Methods

2.1 Hierarchical Teaching Objectives and Project Task Design

The application of Project-Based Learning (PBL) in civil engineering construction courses emphasizes guiding students' multidimensional development through hierarchical teaching objectives. The layering of teaching objectives not only clarifies the learning path but also provides a basis for designing project tasks. Knowledge objectives focus on mastering construction technical principles, construction codes, and standards, ensuring that students possess a solid theoretical foundation; skill objectives emphasize operational requirements such as construction process selection, construction plan preparation, quality control, and safety management, highlighting the integration of theory and practice; competency objectives are reflected in the development of comprehensive abilities, including construction process analysis, engineering decision-making, and team collaboration management. Through hierarchical objective design, students can achieve the integration of knowledge mastery, skill enhancement, and overall competency development in a progressively structured learning process.

In project task design, the course should construct a task chain that closely aligns with the hierarchical objectives and the construction workflow. Each task unit should cover different dimensions of the construction process, such as the rationality of material selection, optimization of construction schedule management, and dynamic control of construction quality, enabling students to continuously strengthen their understanding and mastery of the entire process while completing specific tasks. Task design should not only ensure a close integration of theoretical knowledge and practical operation but also feature progressively increasing difficulty and challenge, allowing students to achieve competency breakthroughs at different stages. The gradual transition from basic operational tasks to comprehensive project-based tasks not only promotes the systematic construction of students' knowledge systems but also helps cultivate their comprehensive ability and adaptability to address complex engineering problems^[3].

2.2 Structuring and Modular Reconstruction of Teaching Content

Structuring and modular reconstruction of teaching content are key steps for the effective implementation of Project-Based Learning (PBL). In civil engineering construction courses, the knowledge system covers multiple modules, including construction principles, construction processes, construction management, and construction technology innovation. Through modular reconstruction, course content can be divided into theoretical modules, operational skills modules, and comprehensive project modules, achieving logical alignment between knowledge points and operational tasks. Structured content not only enhances the course's practicability but also provides students with a clear pathway to systematically master construction knowledge within project tasks, allowing complex construction processes to be broken down into executable learning units.

Modular reconstruction also supports close integration between teaching content and project tasks. Each module delivers core knowledge and is accompanied by corresponding construction tasks or simulated projects, enabling students to internalize knowledge and practice skills during module learning, thereby forming a closed loop from conceptual understanding to operational application. Module design emphasizes hierarchical knowledge progression and the cultivation of comprehensive skills, and cross-module task challenges promote students' integrated application abilities in construction plan design, construction technology analysis, and engineering management. The incorporation of information technology tools, such as construction simulation software, BIM models, and virtual construction environments, further enhances the interactivity and authenticity of modular learning, improving both teaching efficiency and learning outcomes.

2.3 Construction of the Learning Assessment System

Project-Based Learning (PBL) emphasizes the integration of formative and summative assessment, and the construction of a multidimensional learning assessment system can comprehensively reflect students' knowledge mastery, skill application, and overall competency development. Formative assessment focuses on students' performance during project task execution, including indicators such as the quality of construction plan design, completion of operational skills, team collaboration ability, and problem-solving capacity. The results of formative assessment provide immediate feedback to students, guiding adjustments in learning strategies and promoting continuous improvement and competency enhancement. Summative assessment evaluates whether students achieve course objectives and competency development requirements through comprehensive project examinations or completion of module tasks, thereby confirming learning outcomes in a competency-oriented manner ^[4].

The design of the assessment system should balance quantitative and qualitative evaluation methods, addressing both the accuracy and compliance of construction operations and the comprehensive performance in innovation, engineering judgment, and team collaboration. By incorporating peer assessment, teacher evaluation, and self-assessment, a multi-perspective, multi-level evaluation loop is established, fostering students' self-reflection and autonomous learning during project-based learning. Additionally, digital assessment tools, such as BIM construction simulation records, task execution data statistics, and online evaluation platforms, provide scientific evidence for analyzing teaching effectiveness, enabling learning assessment to not only reflect students' competency levels but also guide the optimization of teaching content and improvement of task design, achieving high consistency between course objectives and competency development.

3. Exploration of Techniques and Methods for Implementing Project-Based Learning

3.1 Teaching Resources and Information Technology Support System

The successful implementation of Project-Based Learning (PBL) relies on the systematic integration and optimized allocation of high-quality teaching resources. Civil engineering construction courses cover multidimensional content, including construction processes, material properties, construction equipment, and construction organization management. Relying solely on traditional textbooks and classroom lectures cannot fully present the complexity of the engineering knowledge system. Therefore, course resources should include theoretical textbooks, construction standards and codes, on-site case databases, operational demonstration videos, construction simulation software, and 3D digital models. On this basis, the integration of advanced information technologies such as Building Information Modeling (BIM), Virtual Reality (VR), and Augmented Reality (AR) can not only simulate complex construction scenarios but also visually present interdisciplinary knowledge, enhancing the immersion and practicality of learning. A rich and multidimensional teaching resource system enables students to flexibly select appropriate learning paths at different stages, achieving seamless transitions from theoretical study to skill training ^[5].

Meanwhile, the information technology support system plays a central role in the teaching process. Based on intelligent teaching platforms, it can manage the full process of resource sharing, task assignment, and progress monitoring. Students can access construction standards, download project task briefs, submit operational results, and receive real-time automated analysis and feedback through the platform. Teachers can leverage the platform to construct knowledge maps, provide task guidance, and track learning trajectories, gaining comprehensive insight into students' learning status and competency development. The IT system not only strengthens the organic linkage among teaching content, learning tasks, and assessment but also uses big data analysis to assist instructors in course optimization and personalized instructional design. This dual system of resources and technology ensures that PBL operates efficiently in a multidimensional environment, promoting deep knowledge construction and skill enhancement for students in learning scenarios that combine realistic and digital experiences.

3.2 Teaching Organization Model and Collaboration Mechanism

The teaching organization model is a critical factor for the efficient operation of Project-Based Learning (PBL). The tasks in civil engineering construction courses are comprehensive and complex, requiring the teaching design to fully reflect the multi-role and multi-stage characteristics of

engineering practice. A group-based organization model can effectively decompose complex construction tasks, with each group responsible for a complete learning unit, ranging from construction plan preparation and material and process selection to schedule control and quality inspection. In the process of collaborative division of labor, students are required not only to fulfill individual responsibilities but also to integrate across stages to form an overall solution. This task-chain-based organization model reinforces students' holistic understanding of construction workflows and systems thinking, making the learning process closely aligned with the operational logic of real engineering projects.

The design of the collaboration mechanism ensures the smooth implementation of PBL. Within teams, information communication, task coordination, and phased supervision are essential, and digital collaboration platforms serve as supporting tools for task assignment, progress tracking, and real-time feedback. Teachers act as guides and supervisors during project execution, observing group dynamics and intervening as needed to help students adjust strategies and methods, thereby enhancing decision-making and engineering judgment. Furthermore, cross-group communication mechanisms create a multi-team collaborative environment analogous to real construction settings, fostering students' abilities in resource sharing, conflict resolution, and inter-team coordination. Through the effective operation of the collaboration mechanism, students not only acquire professional knowledge and construction skills but also develop comprehensive competencies such as communication, organizational management, and team leadership in a project-driven environment, laying practical experience and capability foundations for managing large-scale engineering projects in the future.

3.3 Enhancement of Teaching Effectiveness and Sustainable Optimization Pathways

The effectiveness of Project-Based Learning (PBL) relies on continuous monitoring and scientifically grounded optimization pathways. To achieve teaching objectives effectively, it is necessary to establish a data-driven monitoring and assessment mechanism. By collecting and analyzing multidimensional data on students' operational records, project outcome quality, and collaborative performance during task execution, learning outcomes can be comprehensively reflected, and weaknesses in teaching can be promptly identified. Based on this data, instructors can dynamically adjust course content and task design, achieving precise alignment between teaching activities and students' competency development. Through continuous feedback and iterative processes, students gradually optimize their learning strategies, enhancing construction skills, engineering analysis abilities, and teamwork competencies, thereby forming a learning chain that deeply integrates theory and practice [6].

On this basis, constructing sustainable optimization pathways is particularly critical for the long-term development of the course. With the ongoing evolution of construction technologies and information-based tools, course design must possess dynamic adaptability to respond promptly to industry development needs. By establishing a cyclical improvement mechanism, the teaching team can continuously iterate project tasks and instructional strategies based on students' learning outcomes and course performance. The introduction of digital tools provides technical support for this optimization process; for example, BIM platforms can generate construction data, and learning management systems can analyze learning trajectories, providing scientific evidence for subsequent improvements. In the long term, this dynamic optimization not only ensures the stable enhancement of teaching quality but also continually promotes students' in-depth development in areas such as innovation capability, engineering judgment, and systems engineering literacy, thereby forming an expandable and sustainable project-based teaching ecosystem.

Conclusion

Project-Based Learning (PBL) demonstrates high adaptability and practical feasibility in civil engineering construction courses. Through hierarchical teaching objectives, task design, content modularization, and the construction of a multidimensional assessment system, PBL can systematically enhance students' construction skills, engineering analysis abilities, and collaborative competencies. The integration of information-based teaching resources and digital tools further strengthens course interactivity and the realism of task execution, providing students with a multi-level learning experience. Future research may explore continuous optimization of instructional design, the expansion of interdisciplinary project tasks, and the development of intelligent learning management platforms to achieve dynamic iteration of course teaching and sustained competency development, thereby offering

long-term support for instructional innovation and the cultivation of high-quality engineering talents in civil engineering construction courses.

Fund Projects

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