

Application of Project-Based Learning in the Water Conservancy Engineering Project Management Course

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Abstract: *The high-quality development of water conservancy has imposed new demands on talent cultivation. To address the disconnection between theory and practice in the conventional instruction of the Water Conservancy Project Management course, this study comprehensively integrates the project-based teaching approach into the curriculum. The course is characterized by both systematic theoretical foundations and strong practical applicability. Accordingly, a tripartite objective system encompassing knowledge, ability, and quality is established, along with a four-stage progressive project training framework. By embedding authentic engineering scenarios into the teaching process, the approach effectively bridges academic learning and professional practice. This model effectively stimulates students' learning initiative and enhances their core competencies in areas such as project planning and risk management. It provides an actionable paradigm for pedagogical innovation in the Water Conservancy Engineering Management course and offers valuable references for the assessment, evaluation, and curriculum development of other practice-oriented courses.*

Keywords: Project-based learning; Water conservancy engineering; Project management; Teaching reform.

1. INTRODUCTION

At present, China's water conservancy sector is entering a new era, with high-quality development as its central objective. The national 14th Five-Year Plan and a series of major strategic deployments have imposed higher requirements on the construction, operation, and management of water conservancy infrastructure. Meanwhile, higher education is actively advancing the development of "Emerging Engineering Education". Engineering education accreditation has fully embraced the Outcome-Based Education (OBE) philosophy, emphasizing the cultivation of students' ability to solve complex problems [1]. For engineering majors, the cultivation of systems thinking and comprehensive professional qualities is of particular importance. Against the backdrop of national strategies, industry demands, and evolving educational policies, traditional teaching models primarily focused on knowledge transmission. They can no longer meet the demands arising from the complex and interdisciplinary nature of modern water conservancy engineering. There is an urgent need to explore and implement a new teaching model that achieves deep integration and effectively connects the classroom with the industry [2]. This transformation is not only a renewal of teaching methods but also reflects the mission of higher education to respond to national strategic needs and support industrial transformation and upgrading. Ultimately, it lays a solid foundation for cultivating a new generation of water conservancy professionals with engineering literacy, innovative thinking, and a strong sense of responsibility.

Traditional teaching of the *Water Conservancy Project Management* course has tended to emphasize theoretical instruction. As a result, students often lack an intuitive understanding of the full life cycle, systemic nature, and dynamic characteristics of engineering projects. Limited opportunities for practical engagement further weaken the connection between theoretical learning outcomes and practical applications. In the teaching practice of the *Water Conservancy Project Management* course, the project-based teaching approach demonstrates distinct advantages. Given the course's highly specialized and application-oriented nature, this approach effectively integrates authentic industry scenarios into the learning process. While strengthening students' theoretical foundations, it also promotes active participation, thereby enhancing their sense of achievement and practical competence.

2. ADAPTABILITY ANALYSIS OF PROJECT-BASED LEARNING

2.1 Problems in the Teaching of the *Water Conservancy Project Management* Course

At present, the teaching of the *Water Conservancy Project Management* course is confronted with the dilemma of

separation between theory and practice. The content of teaching materials lags behind industrial development, making it difficult for students to transform abstract concepts into engineering judgment. The teaching method remains largely based on one-way knowledge transmission, with classroom instruction still being teacher-centered and lacking problem analysis and task-driven learning in authentic contexts. As a result, students' ability to solve complex engineering management problems is insufficiently developed. The practical component is relatively weak. Students have limited access to actual water conservancy projects, and the effect of knowledge application and transfer is unsatisfactory. Real engineering scenarios are simplified into idealized cases, leading to a mismatch between theory and practice. Students are frequently placed in a passive knowledge-reception mode, which hinders the development of the systems thinking and holistic cognition required to address complex issues in water conservancy engineering. The current assessment system relies excessively on final written examinations, emphasizing the memorization of theoretical knowledge. It neglects essential competencies in project management practice, such as communication, coordination, teamwork, and risk-based decision-making. Such a training model, which emphasizes theory over practice, can no longer meet the demand for interdisciplinary managerial professionals with both theoretical literacy and practical capabilities required by modern water conservancy construction in the new era. Therefore, a systematic reform of the curriculum system and teaching mode is imperative.

2.2 The Theoretical Connotation and Core Elements of Project-based Learning

Project-based learning is a constructivist learning theory and a modern pedagogical approach grounded in situated learning and collaborative learning theories. Centered on authentic and challenging projects, it deeply integrates instructional objectives with project tasks. Students are guided to actively construct knowledge, progressively develop competencies, and comprehensively enhance their overall qualities through the autonomous completion of project work [3].

Project-based learning can break through the linear logic of traditional knowledge transmission and reconstruct a closed teaching loop of "project guidance - task decomposition - exploratory practice - summary and improvement". It regards learning as a process in which learners actively construct meaning through active participation and collaboration in authentic contexts. It also reshapes the power relations within the educational setting. Knowledge authority shifts from the teacher to a community of practice. Within specific contexts, students acquire knowledge through collaboration with others and engagement in real problem-solving activities. Its essence lies in integrating instructional activities with authentic problem-solving scenarios, thereby transforming education from the transmission of knowledge to the cultivation of competencies [4].

2.3 Adaptability Analysis of Project-based Learning and the Course

The *Water Conservancy Project Management* course is a core course for students majoring in Engineering Management and Engineering Cost (Water Conservancy Direction). It integrates both theoretical systematization and practical applicability, and exhibits a strong intrinsic alignment with project-based learning in terms of educational philosophy and implementation pathways [5]. From a disciplinary perspective, water conservancy engineering projects are characterized by systemic complexity, inherent uncertainty, and multidimensional interactions. Their management processes involve multiple domains, including engineering technology, economics, management, society, and ecology. Such complexity provides authentic problem contexts and real-world cases for project-based teaching.

From the perspective of course alignment, the *Water Conservancy Project Management* course focuses on the management of water conservancy project construction and covers key processes such as planning, design, and construction. Project-based learning, which centers on authentic project tasks, aligns closely with the course's project-oriented nature, enabling a precise match in educational philosophy. This alignment helps transform abstract concepts of project management into concrete implementation processes. It is also beneficial for addressing the disconnect between theory and practice in traditional teaching and for integrating course content with practical instructional cases. However, the implementation of project-based learning also faces several challenges. On the one hand, it requires instructors to possess interdisciplinary knowledge and practical engineering experience, placing higher demands on teaching competence than traditional instructional models. On the other hand, real engineering environments are complex, dynamic, and full of uncertainty and risk. If classroom project scenarios are overly simplified, they may fail to fully reflect the complexity of actual engineering projects.

Based on the adaptability analysis, this study proposes a project-based teaching framework consisting of four

instructional stages: project initiation, planning, implementation, and closure. In parallel, a hierarchical competency development system is constructed, comprising foundational skills, comprehensive application abilities, and innovation-oriented enhancement. This design forms a spiral progression of student capability development. In terms of project system design, and guided by cognitive load theory, a graded sequence of micro, medium, and comprehensive projects is established to ensure increasing task complexity. Each project is further assigned explicit competency targets and knowledge anchors. The teaching implementation adopts a “dual-track” model. The explicit track focuses on project task progression, while the implicit track supports systematic knowledge construction. This is operationalized through a three-stage cycle: pre-class knowledge graph preparation, in-class project-based inquiry, and post-class reflection and consolidation. This framework not only preserves the professional rigor of project management but also reflects the characteristics of the water conservancy industry. It provides a systematic and operational teaching model for curriculum implementation [6].

3. CONSTRUCTION OF PROJECT-BASED COURSE TEACHING SYSTEM

3.1 Reconstruction of the Course Objective System

Guided by the principles of project-based learning, the course must move beyond traditional knowledge-oriented objectives and construct a new outcome system that integrates content and practice. At the knowledge level, the original boundaries between textbook chapters and instructional content are removed. A knowledge graph is reconstructed based on the full life cycle of water conservancy engineering projects. Dispersed knowledge points, such as project schedule management, cost management, quality management, and safety management, are systematically integrated into a contextualized knowledge network. At the competency level, clear, operable, and assessable core competency indicators are established. Considering the complexity and practical nature of water conservancy project management, key competencies such as project organization, risk response, team leadership, and technological innovation are systematically defined. A corresponding measurable and evaluable achievement framework is also developed. At the quality dimension, engineering ethics and sustainability principles are integrated into the curriculum. Social responsibility, ecological awareness, and humanistic concern in water conservancy engineering are incorporated into the training objectives. This reconstructed objective system is consistent with the OBE philosophy and reflects the characteristics of the water conservancy industry. It provides clear direction and an evaluative benchmark for the implementation of project-based learning [7].

3.2 Hierarchical Design of the Project System

Based on differences in student learning depth and project content, the complexity of projects is systematically analyzed and gradually increased following a progression from simple to complex. Accordingly, a four-tier progressive project system is designed, including the foundational, enhancement, comprehensive, and innovation levels (as shown in Figure 1). This structure establishes a developmental trajectory from simple to complex tasks and from single-dimensional to integrated competencies [5]. At the foundational level (20%), projects focus on single-skill training and aim to develop basic competencies in applying project management tools. At the enhancement level (30%), projects emphasize the integration of professional modules and cultivate students' ability to solve moderately complex problems. At the comprehensive level (40%), projects simulate the full lifecycle management of water conservancy engineering projects. Large-scale projects with moderate complexity are selected, requiring students to develop complete management plans from feasibility study to project completion. This stage strengthens systems thinking and integrated decision-making capabilities. At the innovation level (10%), emerging technologies such as digital twin systems are introduced to explore new intelligent water conservancy project management models, thereby fostering innovative thinking in engineering management [8].

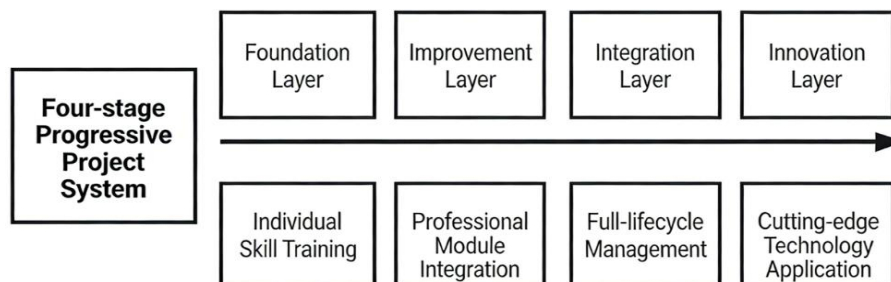


Figure 1: Four-Step progressive project system

3.3 Innovation in the Teaching Implementation Process

At the teaching implementation level, a “dual-cycle and five-stage” instructional process model is constructed. The “dual-cycle” refers to the integration of a macro semester cycle and a micro lesson cycle, which are embedded within each other to form a spiraling learning trajectory [9]. The “five stages” are as follows. (1) Contextual introduction, where authentic problem situations are created through engineering videos, BIM models, and digital twin platforms to stimulate learning motivation. (2) Task decomposition, in which students break down complex projects into manageable sub-tasks and establish a structured work framework. (3) Collaborative inquiry, where students work in groups with each team responsible for different task modules and share knowledge through cross-group discussions. (4) Solution implementation, where water conservancy simulation platforms and project management software are used for schedule simulation, resource optimization, and risk analysis. (5) Reflective consolidation, where structured reflection logs and expert feedback are used to promote experiential internalization and theoretical refinement. In terms of classroom organization, the traditional classroom boundary is transcended, forming a “construction site-laboratory-classroom” triadic teaching environment. This integrates learning contexts with real working environments.

3.4 Multi-dimensional Collaborative Evaluation System

In response to the characteristics of project-based learning, the traditional single-dimensional assessment approach is replaced by a comprehensive evaluation system that integrates instructor assessment and peer evaluation among student groups [10]. Peer evaluation focuses on four dimensions: project completion, content quality, presentation effectiveness, and teamwork performance. Through structured rubrics and feedback sessions, it fosters students’ critical thinking and professional communication skills. Instructor evaluation is conducted from the perspectives of project planning and implementation, individual contribution, and reflective reporting, providing diagnostic and formative assessment. By establishing and implementing this multi-dimensional and collaborative evaluation system, a positive feedback loop of “promoting learning and teaching through assessment” is formed. This approach effectively enhances teaching quality and ensures the achievement of intended learning outcomes.

4. CONCLUSION

This study explores the application of project-based learning in the *Water Conservancy Project Management* course and constructs an innovative teaching system characterized by the integration of theory and practice, as well as balanced development of competencies and professional qualities. By reconstructing a tripartite course objective system of “knowledge-ability-quality,” establishing a four-tier progressive project training framework, and innovating a “dual-cycle and five-stage” instructional process, the proposed model reshapes the relationship between teaching and learning. It effectively addresses the core challenge of weak integration between theory and practice in the traditional instruction of this course, enabling a shift from knowledge transmission to competency cultivation. By embedding authentic engineering contexts and progressive project tasks, this teaching model enables students to actively construct knowledge while engaging in complex project management problem-solving. It also promotes the development of systems thinking and comprehensive managerial capabilities. Furthermore, the proposed instructional framework provides a transferable and referenceable model for teaching reform in engineering management-related courses.

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