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Research on the Reform of BIM Experimental Teaching Based on the OBE Teaching Philosophy: A Case Study of Chengdu Technological University

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Abstract: Based on the Outcomes-Based Education (OBE) philosophy, this study systematically reconstructs the BIM experimental teaching system in response to the new demands placed on engineering cost professionals by the intelligent transformation of the construction industry. Traditional teaching models suffer from difficulties in interpreting two-dimensional drawings, fragmented professional knowledge, and a disconnect between theory and practice, making it challenging to support the training objectives of "digital cost engineers"[1]. To address these issues, this research relies on a real completed comprehensive teaching building project, integrating architectural, structural, mechanical, electrical, and plumbing drawings, as well as quantity take-off lists, to construct a project-driven BIM virtual simulation experimental teaching platform. Three core reform measures were implemented: first, introducing real project resources to deepen the integration of theoretical knowledge and engineering practice; second, adopting a team-based collaborative learning model to enhance students' organizational coordination and cross-disciplinary communication skills; and third, innovatively conducting a "three-calculation comparison" analysis among BIM model quantities, results from traditional measurement software, and manual calculations, aiming to cultivate students' multi-dimensional verification and data-driven decision-making abilities. Teaching practice demonstrates that this model effectively improves students' BIM technology application proficiency, problem-solving capabilities for complex engineering issues, and cross-disciplinary collaboration skills, providing a practical and replicable path for the systematic training of engineering cost professionals in applied undergraduate institutions.

Keywords: Outcomes-Based Education (OBE); Applied Undergraduate Education; BIM Technology; Experimental Teaching Reform

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1. Introduction

Against the backdrop of rapid development in the digital economy and smart construction, the informatization and digital transformation of the construction industry continue to deepen[2]. Building Information Modeling (BIM) technology, as a key tool for managing the entire lifecycle of engineering projects, has extended its application from the design phase to cost estimation, construction, and operational management[3]. This transformation imposes new demands on the knowledge structure and competency of engineering cost professionals. The traditional teaching model, centered on manual calculations and two-dimensional drawing interpretation, has become outdated. Cultivating "digital cost engineers" who possess technical application skills, data-driven thinking, and cross-disciplinary collaboration abilities has become an urgent priority[4].

The Outcomes-Based Education (OBE) philosophy emphasizes focusing on students' final learning outcomes and designing curricula and teaching processes in reverse, providing clear guidance for engineering education reform[5]. Numerous scholars in China have implemented OBE-based teaching practices across various disciplines, validating its effectiveness[6–8]. In the field of BIM education, existing research primarily focuses on software skill training or integrating BIM technology into single theoretical courses[9–10]. However, there remains room for deeper exploration in systematically constructing an experimental teaching system based on real and complex projects, with an emphasis on cultivating students' multi-dimensional verification and engineering decision-making abilities[11].

Therefore, this study, grounded in the training orientation of applied undergraduate education and guided by the OBE philosophy, first clarifies the core competencies required for cost professionals in the context of smart construction. It then designs teaching content and methods in reverse. By integrating real engineering projects throughout the research process and employing strategies such as resource integration, team collaboration, and "three-calculation comparison," this study systematically constructs and implements a new BIM virtual simulation experimental teaching system. The aim is to effectively address the shortcomings of traditional teaching and provide empirical references for the reform of engineering cost education.

2. The OBE Educational Philosophy and Its Instructional Guidance

Outcomes-Based Education (OBE) is an educational paradigm centered on student learning outcomes, characterized by reverse design and forward implementation[12]. Its core principles include "clarity of focus," "expanded opportunities," "high expectations," and "reverse design"[13]. In teaching practice, OBE requires educators to first define the competency goals students should achieve upon graduation, then design the curriculum, teaching content, and assessment methods accordingly, and continuously improve to ensure all students have opportunities to attain high-level goals[14].

This philosophy has achieved significant results in teaching reforms across multiple disciplines in China. For example, Li Qingyi et al. applied the OBE model in medical nursing experimental teaching, enhancing its effectiveness and feasibility[6]; Wu Zufeng et al. focused on engineering competency, fostering students' inquiry and innovation abilities through self-designed experiments[7]; and Fang Bo integrated the OBE philosophy into the professional talent training program, reconstructing the curriculum system and strengthening students' initiative and practical innovation abilities[8]. In the field of civil engineering and construction, Zhang Yanfang et al. constructed a BIM practical teaching framework based on the OBE-CDIO philosophy, effectively improving students' BIM application and comprehensive abilities[15].

The above practices provide important references for this study. Guided by the OBE philosophy, this research first defines the core competencies required for digital cost engineers, such as BIM modeling, multi-source data integration, and cost analysis and decision-making. It then systematically designs the projects, tasks, and evaluation mechanisms for BIM experimental teaching in reverse, ensuring that the teaching process closely aligns with the final learning outcomes.

3. The Development Status and Value of BIM Experimental Teaching

3.1 Current Status of BIM Teaching Development

In response to national policies on construction informatization, universities in China have widely implemented teaching reforms integrating BIM technology into civil engineering and construction-related disciplines[16]. Current practices mainly include integrating BIM with professional courses such as engineering management[17]; incorporating BIM technology applications into courses like civil engineering drafting, architectural design, and steel structures[18]; or combining BIM with graduation design to promote vertical connections among course knowledge[19]. These explorations have yielded positive progress, but most still focus on theoretical teaching or single-skill training, leaving room for improvement in constructing a cohesive experimental teaching system centered on in-depth practice and competency verification[20].

3.2 Core Value of BIM Experimental Teaching in Engineering Cost Education

First, it responds to the inevitable demands of industry digital transformation. In the context of smart construction, BIM skills have become essential for cost professionals. Experimental teaching must transcend software operation and focus on cultivating data-driven cost management abilities[21].

Second, it effectively addresses cognitive barriers in two-dimensional teaching. BIM technology, through three-dimensional visual models, concretizes and integrates abstract two-dimensional drawings and textual calculation rules, helping students intuitively understand spatial relationships and component connections in buildings. It also integrates professional information from architecture, structure, and MEP, solidifying the foundation of professional knowledge[22].

Finally, it serves as a critical pathway for empowering data-driven decision-making abilities. BIM models are engineering databases rich in parameters. Experimental teaching guides students from "modeling" to "using models," enabling real-time cost estimation, scheme comparison, and optimization using model data. This cultivates students' data sensitivity and data-driven engineering economic decision-making abilities, which are core competencies for digital cost engineers[23].

4. BIM Experimental Teaching Reform Strategies Based on OBE

To achieve the transformation from "software operation training" to "project practice and innovation capability cultivation," this study implements the following three core reform strategies.

4.1 Integrating Real Project Resources to Build a Theory-Practice Integrated Teaching Platform

Guided by the OBE philosophy and with industry competency demands as the ultimate outcome goal, this study selects a completed comprehensive teaching building project from teachers' horizontal research topics and integrates its complete real data[24]. This forms a project-driven BIM experimental teaching resource library, and teaching is conducted in a virtual simulation laboratory. Students can engage with real engineering scenarios during their studies, combining theoretical knowledge with complex engineering practice. The modeling process, with physical references, significantly reduces drawing interpretation errors caused by insufficient spatial imagination[25].

4.2 Implementing Team Collaboration Models to Enhance Comprehensive Professional Competencies

The teaching organization adopts project groups of 3–4 students, allowing free team formation and democratic division of labor[26]. Team members are responsible for BIM modeling and quantity analysis of different modules, such as architecture, structure, and MEP, while the group leader coordinates overall efforts. Through regular technical seminars, model integration, and conflict resolution, the entire process simulates the collaborative mode of real engineering project teams. This effectively trains students' soft skills, such as organizational coordination, cross-disciplinary communication, and project management, highlighting students' central role in teaching[27].

4.3 Innovating the "Three-Calculation Comparison" Method to Strengthen Multi-Dimensional Verification and Decision-Making Abilities

The core innovation of this reform lies in introducing the "three-calculation comparison" analysis. Students are required to obtain quantities for the same engineering component using three parallel methods: automatic extraction based on BIM models, calculations using traditional measurement software, and manual calculations strictly based on drawings[28]. Subsequently, students are guided to conduct cross-comparisons and deviation analyses of the three sets of data, exploring the causes of differences and the advantages and limitations of each method[29]. This process not only consolidates students' traditional cost estimation skills but also cultivates critical thinking, data validation abilities, and decision-making capabilities based on multi-source information[30].

5. Conclusion and Outlook

This study, based on the OBE educational philosophy, constructs and implements a BIM virtual simulation experimental teaching system characterized by real projects, team collaboration, and "three-calculation comparison." Teaching practice demonstrates that this model effectively enhances students' in-depth BIM technology application abilities, problem-solving capabilities for complex engineering issues, and cross-disciplinary teamwork skills, achieving the integrated cultivation of knowledge, skills, and competencies. It provides an operable solution for training applied engineering cost professionals[31].

In the future, the team will focus on establishing a quantitative evaluation and continuous improvement mechanism based on OBE attainment, dynamically updating the teaching case library, and further deepening industry-education integration. By incorporating the latest industry technologies, standards, and practical demands into teaching, the teaching system will remain advanced and adaptable, continuously supplying high-quality professional talent for industry transformation and upgrading[32].

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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