Global Research in Higher Education
ISSN 2576-196X (Print) ISSN 2576-1951 (Online)
Vol. 9, No. 2, 2026
www.scholink.org/ojs/index.php/grhe

Original Paper

Exploration and Practice of “Virtual-Real Integration” Hybrid Teaching Mode in the Course of “Construction Engineering Measurement and Pricing” under the Background of Digital Transformation

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Received: March 22, 2026 Accepted: April 2, 2026 Online Published: April 8, 2026

doi:10.22158/grhe.v9n2p8 URL:http://dx.doi.org/10.22158/grhe.v9n2p8

Abstract

With the acceleration of digital transformation in the construction industry, the traditional teaching mode of the “Engineering Construction Measurement and Pricing” course is facing challenges in cultivating students’ ability to interpret drawings, spatial imagination, and practical operation skills. This paper addresses the problems existing in current teaching, such as theoretical disconnection, resource scarcity, and limited practice, and proposes the construction of a “virtual-real integration” blended teaching model. This model uses real engineering projects as the carrier, integrates BIM technology to build a virtual simulation teaching resource library, and combines online self-study with offline project-based teaching, aiming to reshape the teaching process and enhance students’ comprehensive vocational qualities. Teaching practice shows that this model effectively stimulates students’ learning initiative, significantly improves their operational skills of measurement and pricing software and their ability to solve engineering practical problems, providing a new path for cultivating high-quality engineering cost talents who meet the needs of the new era.

Keywords

Construction project measurement and pricing, Blended teaching, BIM technology, Integration of virtual and real worlds, Teaching reform

1. Introduction

Under the guidance of the Digital China strategy, emerging technologies such as Building Information Modeling (BIM), big data, and artificial intelligence are profoundly reshaping the construction industry. Engineering cost, as the core part of construction project management, is transforming from the traditional manual calculation based on two-dimensional drawings to intelligent measurement and full-process cost control based on three-dimensional models. This transformation poses new requirements for the cultivation of engineering cost professionals: students not only need to master solid theoretical knowledge of measurement and pricing, but also need to possess the abilities of digital modeling, collaborative management, and innovative application.

“Construction Engineering Measurement and Pricing” is the core course for the engineering cost major, featuring strong comprehensiveness, high practicality, and strong policy orientation. However, currently there are common problems in teaching: First, teaching resources are abstract, and students lack intuitive understanding of complex building structural nodes and steel bar arrangements, making it difficult to establish spatial imagination; second, “teaching” and “learning” are separated. Traditional “full-class lecture” teaching methods are difficult to stimulate students’ subjective initiative, and the practical training 环节 is restricted by the venue, time, and hardware resources, making it difficult to achieve high-frequency and personalized training; third, teaching content is disconnected from the industry's cutting-edge frontiers, and students’ ability to apply new tools such as BIM technology is insufficient.

To solve these problems, this research is based on the constructivist learning theory and the educational concept of “student-centered”, exploring and practicing the “virtual-real combination” blended teaching model. By integrating online virtual simulation resources and offline physical project practice, the teaching content and process are reconstructed, aiming to solve teaching difficulties, improve teaching quality, and provide effective support for cultivating innovative and applied engineering cost professionals.

2. Construction of the “Virtual-Real Integration” Hybrid Teaching Model

The core of the “virtual-real integration” teaching model lies in deeply integrating the simulation training in the virtual environment with the practical application in the real environment. This course is built based on the Superstar Learning Platform and the Guanglada BIM Measurement and Pricing Software, forming a “three-stage, four-fusion” teaching model.

2.1 Overall Framework of the Teaching Model

1) Online virtual cognition and simulation stage: Using BIM technology to build a three-dimensional model library for typical building components (such as foundations, columns, beams, slabs, walls, stairs), and creating virtual construction animations for key processes. Students complete self-study and basic skill simulation training by watching micro-lessons, disassembling three-dimensional models, and

recording software operations on the online platform before class. Teachers can monitor students' pre-class preparation through platform data.

2) Offline physical deepening and training stage: In the classroom, real engineering drawings (such as a certain frame structure office building) are used as the task carrier, adopting the "project-oriented, task-driven" teaching method. Teachers provide detailed explanations for common problems in students' online learning and organize group discussions, case analyses, and quantity correction. Under the guidance of teachers, students use the BIM measurement software to complete the model establishment, engineering quantity calculation, and list pricing for the designated project, achieving the internalization and application of knowledge.

3) Virtual-real interaction reflection and innovation stage: Comparing the engineering quantity data in the virtual model with actual on-site construction cases or industry pricing references (bidding control price, quota, list) guides students to understand the differences between theoretical calculations and actual construction. Through organizing comprehensive practical projects such as "quantity calculation competition" and "bidding control price compilation", students are encouraged to reflect and optimize in the virtual-real interaction, cultivating their higher-order thinking and innovation ability.

2.2 Construction of the Teaching Resource System

Digitalization of teaching resources is the cornerstone of the "virtual-real integration". The project team systematically constructed three resource libraries:

1) Virtual simulation resource library: For the course's key difficulties, such as complex node reinforcement construction and concrete component engineering quantity deduction rules, Revit and Guanglada software were used to establish 100+ typical components' three-dimensional models, and a series of micro-lesson videos were created. Students can freely rotate, zoom, and section the models in the virtual environment to intuitively understand the spatial relationships and construction methods between components.

2) Project case library: Selecting different types of real engineering drawings (covering brick-concrete, frame, shear wall, etc.) for de-sensitization processing, a "basic-advanced-comprehensive" three-level project case library was constructed. Each case is accompanied by complete construction drawings, calculation books, pricing documents, and typical problem analyses to meet students' differentiated learning needs at different levels.

3) Training task library: Based on the industry standard "Construction Engineering Quantity List Pricing Specification" (GB50500-2013) and the latest quotas of various regions, training tasks covering all sub-items and sub-components of construction (such as earthwork, pile foundation, concrete, steel bars, etc.) were designed. Task design emphasizes the connection with vocational skills level certificates (such as "1+X" engineering cost digital application), achieving the integration of courses and certificates.

3. Teaching Implementation Process

This course is illustrated with 48 hours of study time. Among them, online learning accounts for 30%, and offline practical training accounts for 70%. The specific implementation process is as follows:

3.1 Before class: Task-driven, Online Self-study

Teachers post pre-class task sheets through the teaching platform, including watching a virtual simulation animation about "reinforcement construction of frame columns" and completing a set of pre-test questions about "calculation rules of longitudinal reinforcement and stirrups of columns". Students log in to the platform, watch and operate independently, and record any difficult questions. Teachers analyze the data through the platform to accurately identify the common confusions of students and adjust the offline teaching strategies.

3.2 During Class: Focus on Problems, Interaction between Virtual and Real

1) Scenario creation and problem introduction (15 minutes): Teachers show photos or short videos of the actual site of steel bar binding in the project, introduce the core question of "insertion and length calculation of longitudinal reinforcement in the foundation of column" to stimulate students' interest in exploration.

2) Collaborative exploration and software practice (60 minutes): Students work in groups of 3-4, based on the pre-class study, attempt to use the Guangda GTJ software to complete the modeling and reinforcement engineering quantity calculation of the frame column in the given drawing. The teacher guides the groups around, providing "one-on-one" tutoring for operation difficulties. Encourage groups to show their models to each other, compare calculation results, and discuss differences, guiding students to return to the norms and drawings.

3) Key points explanation and systematic deepening (20 minutes): Teachers provide concentrated explanations for common problems found during the inspection (such as the anchorage and connection settings of longitudinal reinforcement of columns, the calculation method of the number of stirrups, etc.). Use BIM models to dynamically demonstrate the logical relationship between the arrangement of steel bars and the calculation results, visualizing abstract rules to help students build a systematic cognition.

4) Outcome presentation and multi-dimensional evaluation (25 minutes): Randomly select 2-3 groups to present their modeling results and calculation results on the stage, sharing the difficulties encountered and solutions. Teachers and students jointly provide comments from dimensions such as model accuracy, calculation standardization, and software operation proficiency, achieving mutual evaluation and reflection.

3.3 After Class: Expansion and Deepening, Continuous Improvement

After class, students need to complete advanced tasks: Connect the column component model of this class with the subsequent beam and slab models, complete the integration of the floor overall model, and generate the sub-item bill of quantities. Teachers provide additional materials (such as complex node cases, dispute problem analysis) through the online platform, encouraging students with extra abilities to challenge more difficult projects. At the same time, set up a "Q&A forum", where teachers and students jointly discuss difficult questions to form a continuous learning community.

4. Analysis of Teaching Practice Effectiveness

This teaching model was implemented in two rounds in the 2020 and 2021 grades of the engineering cost major at our school (a total of 180 students). Through comparing the test scores of the parallel classes (using the traditional teaching model), questionnaires, and student interviews, significant results were achieved.

4.1 Significant Improvement in Students' Academic Performance

The final comprehensive scores of the two grades (theoretical examination accounts for 40%, software training assessment accounts for 60%) were analyzed. The average score of the experimental class using the blended teaching method was 85.6 points, with an excellent rate (≥90 points) of 32.2%, which was much higher than that of the control class (78.3 points and 18.9%). Especially in the software training assessment, students in the experimental class performed better in terms of modeling speed, calculation accuracy, and the standardization of list item listing.

4.2 Improvement in Students' Learning Initiative and Participation

The results of the questionnaire survey showed that 92.5% of the students believed that the "combination of virtual and real" model was helpful for understanding complex architectural structures; 88.9% of the students stated that the online preview resources made them "have a clear understanding", and the classroom interaction was more active; 86.1% of the students believed that completing projects in groups enhanced team awareness and communication skills. Students mentioned in the interviews: "Previously, I thought the steel bars were very abstract, but now I can draw them one by one in the software and display them in three dimensions. Finally, I understood why it was calculated this way."

4.3 Enhancement of Students' Ability to Solve Complex Problems

Through participating in comprehensive trainings such as "project bidding control price compilation", students demonstrated strong knowledge transfer ability. They could independently consult standards, analyze drawings, and handle changes and claims in engineering projects. In the subsequent internships, employers reported that these students could quickly master BIM measurement and pricing software, had a deeper understanding of engineering issues, and adapted to the position in a significantly shorter time.

5. Reflection and Outlook

Although the “combination of virtual and real” blended teaching has achieved certain results, there are still some challenges in its implementation:

1) Enhancement of teachers’ capabilities: Teachers not only need to be proficient in professional knowledge but also need to master BIM software operation, online course design, and data analysis skills. This requires continuous teacher training.

2) Student learning self-discipline issues: Online learning requires high self-discipline from students, and some students have the phenomenon of “passing courses”. A further improvement of the process assessment mechanism is needed, such as increasing the frequency of online interaction and setting stage tests, to strengthen the monitoring of the learning process.

3) Continuous update of teaching resources: Industry norms and pricing references are constantly updated. The virtual simulation resource library needs to establish a dynamic maintenance mechanism to ensure the cutting-edge nature and accuracy of the teaching content.

In the future, we will further deepen the teaching reform of “combination of virtual and real”, explore the introduction of VR/AR technology into the classroom, and build an immersive learning environment; strengthen cooperation with enterprises, introduce real engineering full-process cost consulting projects, promote “real projects, real work”, and achieve seamless connection between school teaching and enterprise job requirements. At the same time, pay attention to integrating course ideological and political elements organically into the entire teaching process, while imparting knowledge and skills, cultivating students’ craftsmanship spirit, integrity awareness, and patriotism.

6. Conclusion

The teaching reform of the “Construction Engineering Measurement and Pricing” course is an inevitable requirement to adapt to the digital transformation of the construction industry. The “virtual-real integration” blended teaching model, by integrating digital resources, reconfiguring the teaching process, and strengthening practical application, effectively addresses the pain points of traditional teaching and enhances students’ learning experience and comprehensive abilities. Practice has proved that this is an effective teaching model that conforms to the talent cultivation laws of the engineering cost major and has promotional value. In the future, we will continue to explore and innovate, contributing to the cultivation of more high-quality technical and skilled engineering cost professionals.

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