Article

Teaching Reform and Practice of Engineering Bidding and Contract Management Course

Zhaohui Pang[1,*], Caihong Peng[1] and Xing Yuan[1]

[1] Hunan Institute of Technology, Hengyang, China
* Correspondence: Zhaohui Pang, Hunan Institute of Technology, Hengyang, China

Abstract: To address the problems existing in the teaching of Engineering Bidding and Contract Management, this study is grounded in the requirements for curriculum development under the "New Engineering" initiative and emphasizes the central role of students in the learning process. The dialectical relationships among four dimensions of the teaching process-learning, teaching, competition, and practical application-are integrated into the curriculum. Systematic reforms are implemented in terms of course content, teaching methods and approaches, ideological and political education, and course assessment, thereby establishing a four-dimensional integrated teaching reform model of "learning, teaching, competition, and application." The course content is reconstructed based on the actual work process of engineering bidding and tendering. A BIM-based virtual experimental environment is fully utilized to enhance students' ability to learn through practice, while academic competitions are employed to evaluate learning outcomes. In this way, practical application is organically integrated with course teaching.

Keywords: Teaching reform; Engineering thinking; Applied thinking; Competition thinking; innovative thinking

1. Introduction

Engineering education aims to cultivate students' competencies in communication, knowledge and skills, problem-solving, and practical action [1]. Against the backdrop of the rapid development of emerging technologies and changing industrial demands, engineering education faces new requirements for talent cultivation. The "New Engineering" initiative emphasizes new concepts of engineering education, new disciplinary and professional structures, new models of talent cultivation, new standards for educational quality, and a new system of classified development [2]. Therefore, the development of "New Engineering" programs should focus on promoting collaborative education, aligning talent cultivation with national needs, and returning engineering education to authentic engineering practice [3]. As one of the core courses for civil engineering-related majors, Engineering Bidding and Contract Management is characterized by its strong policy orientation, practical applicability, and comprehensive nature. In the context of "New Engineering" education, how to enrich course content, reform teaching methods, improve teaching quality, stimulate students' motivation for independent learning, and enhance their innovation capabilities has consequently become an important issue that urgently needs to be addressed in higher education teaching reform.

Received: 25 June 2026
Revised: 31 July 2026
Accepted: 10 August 2026
Published: 16 August 2026

2. Current Research on Teaching Reform of the Engineering Bidding and Contract Management Course

2.1. Strong Theoretical Orientation and Limited Diversity in Teaching Methods

Traditional teaching content places excessive emphasis on economics, law, and even legal principles, while providing relatively limited coverage of the scope, conditions, methods, and general procedures of construction project bidding. Insufficient attention is

also given to the preparation and review of bidding documents, the preparation of the engineer's estimate or bid control price, and the selection of bid evaluation and contract award methods. To improve teaching effectiveness, scholars have successively proposed approaches such as case-based teaching, large-project-driven teaching, and blended teaching, seeking to deliver knowledge in ways that are more acceptable to students. Case-based teaching requires instructors to collect and select relevant cases so that teaching cases meet the requirements of representativeness, classic relevance, and timeliness, thereby increasing the richness of classroom content [4]. Large-project-driven teaching is based on occupational work processes and constructs a project-based curriculum system oriented toward professional competence, using a large project to connect relevant course content and address problems associated with excessive dependence on textbooks, monotonous teaching methods, low levels of informatization, and weak continuity in traditional teaching [5]. Blended teaching combines the advantages of online and offline learning to create an open and innovative learning environment and expand the depth, breadth, and flexibility of student learning [6]. However, these reforms have not fundamentally changed the inertia of teacher-centered, knowledge-transmission-oriented instruction, and students' ability to solve specific practical problems remains insufficient.

2.2. Insufficient Practical Training and Inadequate Integration of Ideological and Political Education

At present, the practical component of the Engineering Bidding and Contract Management course mainly consists of course design projects. In practice, such projects may sometimes appear to be conducted merely for the sake of completing a design task, making it difficult to effectively develop students' engineering practice capabilities [7]. In response, scholars have successively reformed the practical component. Zhong Lihua and colleagues, for example, used the Guanglianda electronic bidding and tendering platform to enable students to simulate different roles in the bidding process and complete various bidding tasks [8]. Wang Xiuli and colleagues proposed a "BIM technology practical training project approach," using BIM 4D/5D management models and bidding software V6.0 for bidding and tendering training [9]. However, these practical reforms are conducted in virtual environments, and role training tends to be procedural, making it difficult to improve students' ability to respond flexibly to on-site situations. Meanwhile, illegal practices such as unlawful contract awarding, bid rigging and collusive bidding, and "yin-yang contracts" occasionally occur in the construction market. The causes of such violations are closely related to deficiencies in the professional ethics of practitioners. Therefore, in addition to teaching professional knowledge, instructors need to integrate ideological and political elements into both theoretical and practical teaching to guide students in developing appropriate professional ethics. Some scholars have incorporated such elements as patriotism, honesty and integrity, craftsmanship, and awareness of rights into case analyses [10,11]. However, inappropriate selection of cases or mismatching between cases and ideological and political elements may directly affect the depth and effectiveness of ideological and political education within the course.

2.3. Rigid Quantification of Assessment Indicators and Unclear Training Objectives

On the one hand, traditional assessment methods rely mainly on written examinations, using test scores to judge the quality of learning. Such examinations focus more on students' ability to memorize than on their ability to apply knowledge. Memorized knowledge is often fragmented and temporary, making it easy to forget and difficult to integrate into a comprehensive understanding of professional knowledge. Application, by contrast, strengthens students' knowledge and connects individual concepts into an integrated system that is more durable. Traditional assessment methods, however, may cause some students to regard learning merely as a means of passing examinations, preventing them from applying theories of engineering bidding and contract management to engineering practice and limiting the course's contribution to their practical abilities [12]. More fundamentally, score-based assessment makes it difficult to demonstrate how a professional course supports the graduation requirements

in engineering education accreditation. The degree of attainment is difficult to evaluate, and the results of attainment evaluation cannot effectively support continuous improvement in course teaching. Therefore, based on the Outcome-Based Education (OBE) philosophy, course assessment should incorporate three combinations: summative and formative assessment, assessment of practical competence and theoretical knowledge, and assessment of open-ended subjective questions and objective questions [13]. Such an approach can provide a more authentic and comprehensive evaluation of students' ability to apply learning outcomes while promoting the development of their professional competencies.

3. Reform Measures

From the perspective of the requirements of "New Engineering," this reform emphasizes students' central role in the learning process and explores effective ways to connect learning, teaching, competition, and practical application. It attempts to transform the course from a predominantly theoretical course into a practice-oriented course and move the teaching environment from conventional classrooms to BIM virtual laboratories. A four-dimensional integrated curriculum system of "learning, teaching, competition, and application" is developed for Engineering Bidding and Contract Management, with emphasis on cultivating engineering thinking, applied thinking, competition-oriented thinking, and innovative thinking among students majoring in civil engineering-related disciplines. Taking students majoring in Engineering Cost and Engineering Management at Hunan Institute of Technology as the research subjects, the reform seeks to improve the traditional teaching situation, better serve the cultivation of innovative and application-oriented talents, and provide practical reference for curriculum development under "New Engineering," the cultivation of outstanding engineers, and the reform of higher engineering education.

3.1. Learning-Guided Learning in Contexts to Cultivate Engineering Thinking

The reform emphasizes students' central role in learning. Instructors create scenarios based on actual bidding and tendering workflows and employ approaches such as real-project-driven learning, occupational role-playing, and virtual simulation using sand-table platforms to facilitate autonomous learning and guide students in developing professional knowledge through contextualized practice. Supported by big-data technologies, an all-stage blended learning system covering before, during, and after class is established. Before class, students complete online learning resources and corresponding tasks based on assignments provided by instructors and engage in group discussions. During class, students listen to explanations of key and difficult points, complete practical training tasks, and participate in simulated scenario exercises in groups according to assigned roles. After class, students participate in disciplinary competitions, visit electronic bidding sites at internship bases, and prepare reports summarizing their learning outcomes.

3.2. Teaching-Process-Oriented Teaching to Enhance Applied Thinking

3.2.1. Reconstruction of Course Content

The course content is reconstructed according to the graduation requirement indicators using a framework of vertical classification, horizontal stratification, and an integrated three-dimensional structure. This produces the "633" logical structure of the course. The first "6" refers to six stages in the engineering bidding and tendering workflow: enterprise registration and filing, project tendering, project bidding, bid opening/evaluation/award, contract signing, and construction claims. These correspond to six teaching modules. The first "3" refers to three occupational roles arranged vertically according to job categories: bidding specialists, tendering specialists, and bid evaluation experts. The second "3" refers horizontally to three levels of talent-development objectives: knowledge objectives, competence objectives, and quality-oriented objectives. The reconstructed "633" logical structure is shown in Figure 1.

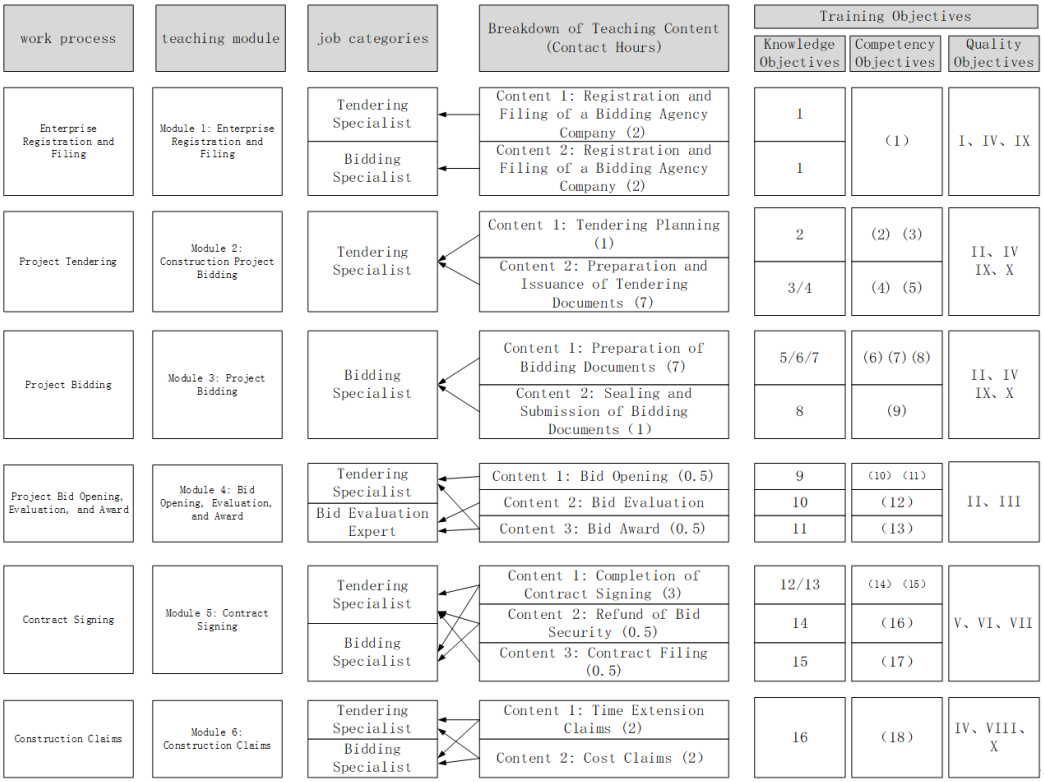

Figure 1. The "633" Logical Structure Diagram of the Reconstructed Course

Knowledge objectives: 1.understand the considerations involved in enterprise registration and filing; 2.understand the conditions, methods, scope, and procedures of project tendering; 3. master the preparation of bidding documents; 4. master the procedures for filing and issuing bidding documents; 5. understand the considerations involved in site surveys; 6. master the preparation of bid documents; 7. master quotation techniques and bidding strategies; 8. understand the requirements for submission of bid documents; 9. understand bid-opening procedures and relevant legal provisions; 10. master bid-evaluation procedures and relevant legal provisions; 11. understand legal provisions concerning the announcement of award results and notices of award; 12. become familiar with the main contents of model contracts; 13. master key considerations in contract negotiation and signing; 14. understand legal provisions concerning the return of bid security; 15. understand relevant knowledge of contract filing; and 16. master claim procedures and claim calculation.

Competence objectives: (1) ability to complete enterprise registration and filing; (2) ability to determine bidding conditions and bidding methods; (3) ability to prepare bidding plans; (4) ability to prepare bidding documents and the bid control price; (5) ability to operate the issuance and filing of bidding documents; (6) ability to organize site surveys; (7) ability to prepare bid documents; (8) ability to apply bidding strategies and appropriately select quotation techniques; (9) ability to manage and submit bid documents; (10) ability to organize bid opening and evaluation in an orderly manner as the tenderer; (11) ability to participate in bid opening and evaluation as a bidder; (12) ability to conduct bid evaluation as a technical and economic expert; (13) ability to accurately issue award announcements and notices of award; (14) ability to negotiate and sign contracts; (15) ability to forecast project development and mitigate risks; (16) ability to manage the return of bid security; (17) ability to complete overall contract filing; and (18) ability to calculate construction-period and cost claims.

Quality-oriented objectives: I. patriotism; II. awareness of the rule of law; III. commitment to fairness; IV. craftsmanship; V. honesty and integrity; VI. confidence and equality; VII. professional ethics; VIII. awareness of rights; IX. teamwork; X. innovation.

3.2.2. Reform of the Teaching Model

Teaching-model reform has attracted considerable research attention in recent years, with the flipped classroom becoming a particularly prominent topic in educational practice. The flipped classroom seeks to change the passive learning status of students and enable them to become the "owners" of the classroom. In practice, however, some students show low levels of participation, and discussions may become merely formal. To achieve greater diversity in teaching models and genuinely implement the principle of combining students' central role with teachers' leading role, the traditional "three-step" flipped classroom model is innovated into a "four-step" model: pre-class video viewing, core-content instruction, team-based practice, and summary and enhancement.

Pre-class video viewing: In accordance with the logical relationships of the work process and the teaching schedule, instructors release learning tasks in advance. Before class, students preview the relevant instructional videos and discuss and design the assigned content in groups.

Core-content instruction: Instructors explain the theoretical knowledge and technical competencies associated with modular tasks using different approaches. For example, heuristic teaching can be used when explaining enterprise registration and filing and contract registration, while case-based teaching can be adopted for engineering tendering, project bidding, bid opening/evaluation/award, and construction claims. At the same time, patriotism, awareness of the rule of law, contractual spirit, craftsmanship, and innovation are subtly integrated into professional teaching content and cases related to engineering bidding and contract management.

Team-based practice: Team-based practice is the key component. Task implementation teams of 8-10 students are formed on the BIM sand-table platform. Students assume different roles, including enterprise registration and filing, tendering, bidding, bid opening, bid evaluation, contract award, and contract signing, and simulate the corresponding work tasks, enabling them to learn through practice.

Summary and enhancement: Students analyze their individual gains, existing problems, and causes during implementation and submit learning-outcome reports, which are incorporated into the calculation of regular assessment scores. Instructors summarize the course teaching based on students' learning reports.

The entire teaching process is conducted in a virtual simulation environment in which instructors and students participate jointly. Students are encouraged to identify and solve problems. Based on the attainment requirements for knowledge and competence objectives, students learn and practice in authentic contexts, thereby developing comprehensive professional qualities and capabilities required in actual occupational positions, including dedication to work, teamwork, interpersonal communication, and the courage to innovate.

3.3. Competition-Testing Learning Outcomes through Competitions to Develop Competition-Oriented Thinking

For application-oriented undergraduate institutions, the talent-development objectives of engineering majors should emphasize the cultivation of students' application-oriented competence, occupational practical competence, and professional competence. The disciplinary competitions associated with this course cover national, provincial, and university levels, including the National College BIM Application Skills Competition in bidding and tendering, professional competitions in engineering cost estimation, and software application competitions in the cost-estimation industry. In addition to assessing students' accumulation of knowledge, disciplinary competitions place greater emphasis on the application of knowledge. Competitions can stimulate students' interest in learning and test their hands-on and practical application abilities. According to the specific characteristics of the major, course assessment can be effectively connected with disciplinary competitions to improve teaching effectiveness. To increase students' enthusiasm for participating in BIM application skills competitions, the course assessment criteria for Engineering Bidding and Contract Management may explicitly allow competition performance to replace examinations; for example, the results of a

university-level selection competition for the BIM Application Skills Competition, in which all students participate, may be used in place of the final written examination.

3.4. Application-Developing through Practice to Enhance Innovative Thinking

Based on the engineering process, the course system is organized into six modules and uses real engineering projects as its carriers. Modular teaching facilitates the analysis of specific problems and, through repeated practice in solving concrete problems, strengthens students' awareness of innovation and gradually improves their innovative capabilities. Combined with virtual and physical practice components, including BIM sand-table training, disciplinary competitions, and off-campus internships, the course further promotes students' mastery of specific business operations in engineering bidding and contract management.

4. Reform Outcomes and Prospects

4.1. Effects of the Reform

The performance of a discipline or project team depends on the effectiveness of task allocation and collaboration among all team members. In general, the positive effects generated by teamwork are evident. Through continuous reform, students majoring in Engineering Cost and Engineering Management at Hunan Institute of Technology have achieved substantial results in disciplinary competitions in recent years, including 12 national grand prizes, 25 first prizes, 18 second prizes, and more than 70 awards at other levels, with more than 100 person-times receiving awards in total. Nevertheless, some students have demonstrated insufficient commitment to learning or poor cooperation during teamwork. How to mobilize the enthusiasm of every student and make full use of each student's strengths remains an issue that needs to be considered in practice.

4.2. Prospects

At present, there is no corresponding textbook specifically organized according to actual work processes. Therefore, during the reform, a key issue is how to integrate general textbooks appropriately with the reformed course modules. At the same time, the development and supplementation of teaching cases require careful preparation by instructors.

5. Conclusion

This study addresses the problems of the Engineering Bidding and Contract Management course, including the disconnect between theory and practice, the lack of diversity in teaching methods, and rigid assessment approaches. Based on the requirements of "New Engineering" education, a four-dimensional integrated teaching reform model of "learning, teaching, competition, and application" was developed. By reconstructing course content according to the actual work process of engineering bidding and tendering, implementing contextualized and process-oriented teaching through a BIM-based virtual experimental environment, and effectively integrating disciplinary competitions with course assessment, the reform promotes the integration of knowledge acquisition, competence development, and practical application. The reform practice demonstrates that this model can enhance students' engineering thinking, applied thinking, competition-oriented thinking, and innovative thinking, while improving their ability to solve practical engineering problems. It has also produced notable achievements in disciplinary competitions. Future research should further improve the development of work-process-oriented textbooks and teaching cases, continuously optimize course modules and teaching resources, and provide more systematic support for the cultivation of application-oriented engineering talents.

Funding: This paper was supported by Hunan Provincial Teaching Research and Reform Project (HNJG-20231303); Hunan Provincial First-Class Undergraduate Course (2020): Computer-Aided Estimation and Budgeting.

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