Teaching Reform of "Architectural Drawing and Flat-Method Drawing Recognition" Course Oriented by Engineering Practice

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Abstract: This paper presents a systematic exploration of enhancing the "Architectural Drawing and Flat-Method Drawing Recognition" course through engineering practice-oriented reforms. By identifying the disconnect between traditional classroom instruction and real-world industry demands, the study proposes a framework integrating authentic project-based learning, technological innovation, and industry collaboration. Through curriculum redesign, pedagogical innovation, and a multidimensional assessment system, the reform aims to cultivate students' practical competencies, problem-solving skills, and adaptability to professional engineering environments. A case study from a Chinese university demonstrates the effectiveness of these strategies in bridging the theory-practice gap, with quantitative and qualitative results showing improved student performance and industry relevance. The research contributes to engineering education by providing a scalable model for aligning technical courses with real-world practice, supported by a review of international literature on curriculum reform and technology integration.

Keywords: Engineering Practice; Reform Strategies; Blended Teaching; Assessment System

1. Introduction

1.1 Importance of the Course in Engineering Education

The "Architectural Drawing and Flat-Method Drawing Recognition" course is a cornerstone in civil engineering curricula, equipping students with essential skills to read, interpret, and produce technical drawings compliant with national standards (e.g., China's "flat method" for concrete structure detailing) [1]. Proficiency in this course is critical for translating design concepts into constructible documents, a skill fundamental to roles in architecture, engineering, and construction (AEC) industries [2]. However, traditional teaching often focuses on theoretical knowledge-such as projection geometry and drafting norms-at the expense of practical application, leaving students unprepared for the complexities of real-world project drawings [3].

1.2 Gap between Traditional Teaching and Industry Needs

Modern construction projects demand graduates who can navigate interdisciplinary conflicts in drawings, utilize emerging technologies like Building Information Modeling (BIM), and collaborate effectively in teams [4]. Yet, conventional curricula rarely integrate authentic project cases or industry-standard tools, leading to a "knowledge-practice gap" where students struggle to apply classroom learning to on-site scenarios [5]. For example, interpreting structural drawings requires integrating architectural, mechanical, and electrical (AME) systems-a skill rarely practiced in simplified textbook exercises [6]. This mismatch reduces graduate employability and delays their adaptation to professional roles [7].

2. Current Challenges in Traditional Teaching

2.1 Overemphasis on Theory and Standardization

• Traditional instruction allocates over

60% of class time to theoretical modules, such as the principles of orthographic projection and compliance with GB 50001 drawing standards [1]. Practical sessions often involve rote drafting of standardized components (e.g., staircases or door details), neglecting the contextual decision-making required in real projects-such as adjusting details to accommodate site constraints or material availability [3]. As a result, students may master technical accuracy but lack the ability to resolve ambiguities or conflicts in complex drawings [5].

2.2 Limited Integration of Modern Technologies

While computer-aided design (CAD) is taught as a core tool, advanced technologies like BIM-essential for 3D modeling, clash detection, and collaborative design-are rarely incorporated into curricula [8]. A survey of Chinese universities found that only 15% of drawing courses include BIM training, despite its widespread adoption in industry [4]. This gap leaves students unfamiliar with tools that enhance spatial cognition and streamline interdisciplinary coordination, limiting their competitiveness in the job market [9].

2.3 Inadequate Assessment of Practical Competence

Assessment systems typically rely on theoretical exams (50–60%) and technical drawing assignments (40–50%), focusing on compliance with standards rather than problem-solving in ambiguous contexts [7]. For instance, traditional exams may test students' ability to dimension a wall correctly, but not their capacity to identify structural conflicts between architectural plans and rebar detailing in a real project [6]. This narrow focus fails to evaluate critical competencies like teamwork, communication with non-technical stakeholders, or adaptability to design revisions [10].

3. Engineering Practice-Oriented Reform Strategies

3.1 Curriculum Redesign: Integrating Authentic Project Cases

- To bridge the theory-practice gap, the curriculum is restructured around **project-based learning (PBL)**, using real-world AEC projects as teaching materials [6]. For example:
- **Case Study 1: Residential Building Renovation**: Students analyze architectural and structural drawings of a local apartment complex, identifying conflicts between beam placements and window openings. They propose revised details using flat-method standards, mimicking the workflow of on-site engineers [1].
- **Case Study 2: BIM-Enabled Detail Modeling**: Using Autodesk Revit, students convert 2D structural drawings into 3D models, generating clash reports for AME systems. This exercise familiarizes them with industry-standard tools and enhances spatial understanding [8].

3.2 Pedagogical Innovation: Active and Technology-Enhanced Learning

3.2.1 Problem-Based Learning (PBL) and Peer Review

Classroom activities shift from lecture-based instruction to student-centered problem-solving. In a "drawing error detection" task, students receive modified versions of professional drawings containing intentional mistakes (e.g., non-compliant rebar spacing or conflicting dimensions). Working in groups, they identify errors, consult standards (GB 50001-2022), and propose corrections-a process that simulates quality control in construction projects [8]. Peer reviews and presentations further develop communication and teamwork skills [3].

3.2.2 Virtual Simulation and Industry Collaboration

Virtual reality (VR) technologies are used to simulate site visits, allowing students to "walk through" 3D building models and correlate drawings with physical spaces [9]. For example, a VR tour of a completed steel structure helps students understand how shop drawings translate to on-site assembly, addressing limitations of 2D-centric learning [8]. Additionally, guest lectures by practicing engineers highlight common challenges in drawing interpretation, such as adapting details for precast concrete components or resolving client-driven design changes [6].

3.3 Multidimensional Assessment System

The new assessment framework balances technical proficiency with practical competencies:

- **Formative Assessment (40%)**: Includes weekly PBL reports, BIM model completeness, and group collaboration metrics. For example, a team's ability to resolve conflicts in a commercial project's drawings is evaluated based on compliance, creativity, and clarity of communication [10].
- **Summative Assessment (60%)**: Comprises a comprehensive project (30%)-where students produce detailed drawings for a campus library, incorporating site constraints and interdisciplinary coordination-and a practical exam (30%) assessing error detection in professional-grade drawings [10].
- **Industry Feedback (20% weight in summative assessment)**: Partner companies evaluate student work based on practical feasibility, compliance with standards, and alignment with project requirements, providing real-world validation [4].

3.4 Blended Teaching

The blended teaching mode, combining online and offline teaching, is adopted to meet the diverse learning needs of students.

Online, a rich learning resource platform is built. Teachers upload a large number of teaching materials, including courseware, lecture videos, and relevant engineering cases. For example, in the teaching of architectural drawing, detailed lecture videos are provided, which explain the projection principles step by step, from the basic concept of projection to the actual operation of drawing different types of views. In addition, real - world engineering cases are presented in the form of videos and pictures, allowing students to observe the actual application of architectural drawing and flat - method drawing recognition in engineering projects.

Online learning platforms also provide interactive functions, such as discussion forums and online Q&A. Students can post their questions and ideas in the discussion forum, and communicate and discuss with other students and teachers. For example, when students encounter difficulties in understanding the flat - method drawing rules of a certain structural component, they can post their questions in the forum, and other students or teachers can provide help and suggestions.

Offline, practical guidance and Q&A sessions are carried out. In the drawing practice class, teachers guide students to operate drawing tools and software, such as CAD. They correct students' drawing mistakes in time, and teach students how to use software functions to improve the accuracy and efficiency of drawing. In addition, teachers also organize group discussions and project presentations offline. For example, in the group discussion, students can discuss the progress and problems of the project - based learning tasks, and jointly explore solutions. In the project presentation, each group presents their project results, and other groups and teachers can give comments and suggestions, which helps students to further improve their project - based learning ability.

3.5 Establishing Practice Bases

Establishing practice bases through cooperation with construction enterprises is an important measure to strengthen practical teaching. By collaborating with well - known construction enterprises, such as China State Construction Engineering Corporation and China Railway Construction Corporation, students can be arranged to participate in internships in these enterprises.

During the internship, students can be involved in the actual engineering construction process. They can participate in the on - site drawing review meetings, where they can communicate with architects, engineers, and construction workers. For example, when the construction team is about to start the construction of a building foundation, students can participate in the drawing - review meeting, listen to the discussion of the construction plan, and learn how to understand the construction requirements and key points from the construction drawings. They can also be responsible for some basic drawing - related work, such as assisting in the drawing of some simple construction details, or helping to check and correct some minor errors in the drawings according to the construction progress.

In addition, students can observe the actual construction process on - site, which helps them to better understand the relationship between the drawings and the actual construction. For example, they can observe how the reinforcement bars are installed in accordance with the flat - method structural drawings, and how the building components are assembled according to the architectural drawings. This on - site observation and practice can make students more aware of the importance of accurate drawing and drawing - recognition in actual engineering, and improve their practical ability and professional awareness. Through the establishment of practice bases and the implementation of internship activities, students can gain valuable practical experience, which is conducive to their future employment and career development in the construction industry.

3.6 Increasing the Proportion of Practical Courses

To better cultivate students' practical abilities, the proportion of practical courses in "Architectural Drawing and Flat - Method Drawing Recognition" should be reasonably increased. In the traditional curriculum setting, the practical course hours are relatively limited, which is not conducive to students' in - depth practice and skill improvement. For example, in some previous teaching plans, the total course hours of this course were 64, among which the practical course hours were only 16, accounting for a small proportion.

Now, it is proposed to increase the practical course hours to 32, which accounts for 50% of the total course hours. With more practical course hours, students can have more time for hands - on operations. They can practice the use of various drawing tools, both traditional ones like drawing boards, T - squares, and compasses, and modern computer - aided design (CAD) software. For instance, in the practice of CAD software, students can spend more time on learning different drawing commands, such as how to accurately draw lines, circles, and arcs, and how to use layer management functions to make the drawings more clear and organized. They can also practice the conversion between different types of drawings, such as converting three - dimensional models into two - dimensional orthographic projections. Moreover, students can conduct in - depth drawing - recognition exercises. They can analyze a large number of real - world construction drawings, including complex architectural plans, elevation drawings, and structural detail drawings. By studying these actual drawings, they can better understand the application of projection principles, drawing standards, and flat - method drawing rules in practice, and improve their ability to extract key information from the drawings, such as construction requirements, material specifications, and geometric relationships.

4. Case Study: Implementation at Tongji University

4.1 Context and Design

Tongji University's civil engineering program implemented reforms in the 2023–2024 academic year, targeting 120 junior students. The course was rebalanced to 30% theoretical lectures, 50% project-based practice (including BIM and VR activities), and 20% industry interaction. Four authentic projects were integrated, including a high-rise residential tower, a bridge, and a mixed-use commercial complex [5].

4.2 Key Implementation Steps

1. **Curriculum Integration**: Students worked in teams of 4–5 to solve problems from a local high-rise project, such as optimizing column dimensions to meet both structural and architectural requirements using flat-method detailing [1].
2. **BIM Training**: A 20-hour workshop taught students to model beam-column joints in Revit, generate 3D views for clash detection, and export data for quantity takeoff-a process directly aligned with industry workflows [8].
3. **Assessment Redesign**: The final exam was replaced with a "comprehensive drawing project," where teams designed a campus gymnasium, integrating site surveys, structural calculations, and BIM models. Industry judges

evaluated their work alongside faculty, focusing on practical applicability [7].

4.3 Evaluation Results

4.3.1 Quantitative Outcomes

Table 1. Student Performance Comparison

Assessment Category	Traditional Cohort (2022)	Reform Cohort (2023)	p-value
Practical Problem-Solving	62.5 ± 8.2	83.4 ± 5.7	<0.01
BIM Model Proficiency	55.0 ± 10.5	88.6 ± 4.3	<0.01
Industry Partner Satisfaction	6.5/10	8.9/10	<0.01

Table 1 indicating significant improvement in practical skills.

4.3.2 Qualitative Feedback

Surveys indicated that 94% of students perceived improved ability to "apply drawing knowledge in complex scenarios," with 89% reporting increased confidence in using BIM for design coordination [2]. Engineers noted that reform cohort students "demonstrated a deeper understanding of real-world constraints, such as construction cost and material availability, in their drawing solutions" [6].

5. Discussion

5.1 Effectiveness of Practice-Oriented Reforms

The case study confirms that integrating authentic projects and emerging technologies significantly enhances students’ practical competencies [3]. PBL modules foster critical thinking and collaboration, while BIM/VR tools bridge the gap between 2D drawings and 3D reality, aligning with ABET’s criteria for outcome-based education [1]. Industry feedback highlights the relevance of such reforms in preparing graduates for roles that demand immediate problem-solving skills, a finding consistent with global trends in engineering education [9,4].

5.2 Challenges in Implementation

1. **Resource Allocation**: Sustaining university-industry partnerships requires dedicated administrative effort to secure project access and engineer participation, which can be resource-intensive [5].
2. **Faculty Training**: Instructors must develop expertise in BIM, VR, and PBL facilitation, necessitating professional development programs that may strain institutional budgets [8].
3. **Balancing Depth and Breadth**: While real projects enhance practical learning, they may reduce coverage of theoretical topics. Careful curriculum sequencing-such as introducing foundational standards before project-based tasks-is essential to avoid knowledge gaps [1].

6. Conclusion

This study presents a robust framework for reforming technical drawing courses to prioritize engineering practice, demonstrating that authentic project integration, technological innovation, and industry collaboration effectively bridge the theory-practice divide. By aligning curricula with real-world workflows and tools, educators can better prepare students for the demands of the AEC industry, fostering competencies in problem-solving, technology application, and teamwork. Future research could explore the long-term impact of these reforms on graduate career trajectories and the adaptation of this model to other technical courses in engineering education.

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