



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 8, August 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.524

 9940 572 462

 6381 907 438

 ijirset@gmail.com

 www.ijirset.com

Research on Teaching Reform of the " Principles and Methods of Construction " Course: A Case Study of Hunan City University

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ABSTRACT: As a compulsory course in the civil engineering major, the "Principles and Methods of Construction" is characterized by a high level of comprehensiveness and practicality. The necessity of research on the teaching reform of this course is first analysed, followed by a review of the course's characteristics and the primary issues present in the current teaching approach. Drawing from several years of personal teaching experience, specific measures for course teaching reform are proposed in four aspects: optimizing course content, improving teaching methods, cultivating practical skills, and reforming evaluation methods. Teaching practice has demonstrated that the proposed reform measures are well-received by students and have resulted in significant improvements in teaching outcomes. The research findings of this study can provide valuable references for course reform at other universities.

KEYWORDS: Principles and methods of construction, Optimizing course content, Improving teaching methods, Cultivating practical skills, Reforming evaluation methods.

I. INTRODUCTION

Most undergraduate graduates majoring in civil engineering in China choose to work on construction sites upon employment. Therefore, almost all universities in China offering civil engineering majors include the course "Principles and Methods of Construction." As a fundamental professional course in civil engineering, the primary goal of "Principles and Methods of Construction" is to equip students with basic theories, methods, and techniques of civil engineering construction, to develop their abilities in construction organization and management, to enhance their problem-solving skills, and to foster innovation awareness. This foundation is intended to prepare them for future engineering practice and to contribute to the development of the industry.

However, in some Chinese universities, the teaching of the "Principles and Methods of Construction" course is currently facing several issues, such as outdated course content, a heavy emphasis on theoretical knowledge, insufficient integration of interdisciplinary knowledge, and a relatively simplistic course evaluation system. These issues have resulted in unsatisfactory teaching outcomes that fail to meet the established teaching requirements [1].

In response to the aforementioned situation, the teaching reform of the "Principles and Methods of Construction" course at the School of Civil Engineering, Hunan City University in China, is taken as an example. The main characteristics of this course and the current issues in its teaching are first reviewed. Drawing on several years of teaching practice and experience, corresponding suggestions and recommendations for course teaching reform are proposed, which may serve as a reference for fellow educators in the field of civil engineering.

II. THE COURSE CHARACTERISTICS AND THE MAIN ISSUES IN COURSE TEACHING

In the undergraduate curriculum of civil engineering, the "Principles and Methods of Construction" course is a compulsory subject that encompasses a variety of fundamental principles and methods related to construction within the civil engineering field. The course covers multiple modules, including earthwork engineering, foundation engineering, masonry engineering, concrete engineering, structural installation engineering, principles of flow construction, network planning techniques, and the overall design of construction organization [2]. This course requires students not only to have a solid theoretical foundation but also to master specific practical operations and management methods. The course content is interdisciplinary, involving knowledge from mechanics, materials science, structural

Volume 13, Issue 8, August 2024**|DOI: 10.15680/IJIRSET.2024.1308076|**

engineering, surveying, machinery, and management, among others. The content is extensive, with numerous and fragmented knowledge points, which contributes to its high level of comprehensiveness and practicality [3]. As construction technologies and methods continue to evolve, the course content must be continuously updated to reflect the latest technologies and practices. The course is primarily derived from engineering practice but also requires theoretical knowledge to optimize and improve this practice. The effective teaching and learning of this course depend on the constant integration of theory with practice. However, the continual reduction in the allocated teaching hours for this course has resulted in very unsatisfactory teaching outcomes.

After extensive research, the main issues in the teaching of the "Principles and Methods of Construction" course have been summarized as follows:

- (1) Disconnection between course content and industry development. The construction industry is continuously advancing in terms of technology and methods. However, the pace at which the course content is updated may not keep up with the rapid development of the industry, resulting in students generally lacking knowledge of the latest construction technologies and management methods.
- (2) Insufficient integration of interdisciplinary knowledge. Civil engineering involves not only structural and construction techniques but also intersects with multiple disciplines. If the course content is limited to construction techniques alone, students' knowledge structure may lack comprehensiveness.
- (3) Insufficient case-based teaching. There are many complex problems and unique solutions encountered in actual construction processes. However, the cases used in the classroom may be few in number or not sufficiently representative, making it difficult to fully convey the complexity and diversity of the industry.
- (4) Inadequate integration of theory and practice. Civil engineering is a highly practical discipline, yet some institutions allocate relatively few hours for practical teaching in this course. As a result, students lack hands-on experience and remain confined to theoretical knowledge, making it challenging for them to fully understand and apply what they have learned.
- (5) Insufficient cultivation of innovation capabilities. The teaching may focus more on traditional construction techniques and methods, with a lack of emphasis on developing students' innovation abilities. For instance, there may be insufficient instruction on how to use new technologies and materials in construction or how to apply information technology in construction management.
- (6) Limited practice bases and experimental conditions. Some institutions may lack sufficient practice bases or laboratory facilities, preventing students from conducting construction experiments in real or simulated environments, which negatively impacts the learning outcomes.
- (7) Monolithic course evaluation system. If course evaluation relies primarily on written exams, it may fail to comprehensively assess students' practical skills and overall competencies. Therefore, it is imperative to propose diversified assessment methods to comprehensively evaluate students' learning outcomes.

III. SPECIFIC MEASURES FOR COURSE TEACHING REFORM

In response to the aforementioned issues, this paper proposes specific measures for course teaching reform, focusing on optimizing course content, improving classroom teaching methods, emphasizing the integration of theory and practice, and reforming assessment methods. These measures aim not only to enhance the effectiveness of course teaching but also to help students adapt to the latest developments in the industry, improve their practical skills, foster innovation, and strengthen their ability to collaborate across disciplines. The ultimate goal is to cultivate civil engineering professionals who are better equipped to meet the demands of modern society and the industry.

3.1 Optimizing course content to enhance students' interest in learning

The selection of course content is a concrete reflection of the professional training objectives and is essential for ensuring teaching quality. The content of the lectures should closely align with the syllabus while also allowing for flexibility beyond it. Therefore, instructors must carefully curate the teaching material and meticulously design each lecture, highlighting the scientific rigor and contemporary relevance of the course theory. The specific reform measures are as follows:

- (1) Continuously updating course content to meet industry development needs.

With the development of the civil engineering industry, new technologies, materials, and methods are continually emerging. For example, the applications of emerging technologies such as 3D printing in construction [4], 3D laser scanning [5], green construction techniques [6], Building Information Modeling (BIM) [7], and intelligent buildings [8]

are becoming increasingly prevalent in the civil engineering industry. Traditional teaching content and methods may not adequately reflect these changes, making it difficult for students to meet the demands of modern engineering practice. Therefore, it is necessary to incorporate the latest industry developments and technologies into the curriculum. This can be achieved by inviting industry experts to deliver lectures or special reports, sharing the latest construction technologies and practical experiences to cultivate students' sensitivity to new technologies and their application capabilities, thereby sparking their interest in future technologies. Additionally, collaboration with construction companies can provide insights into industry needs and the latest trends, enabling timely adjustments to teaching content. It is also essential to emphasize the importance of construction standards to students, as these standards form the basis for quality control and acceptance in civil engineering projects. During lectures, instructors should consciously develop students' ability to learn and apply new standards, ensuring they are well-prepared to adhere to and implement these standards in their future careers. 3D printing technologies, 3D laser scanning technologies and green construction techniques are shown in Figure 1 to Figure 3, respectively.



Fig. 1 The 3D-printed house constructed in Qingpu, Shanghai



Fig. 2 The 3D scanning of the Wujiang Bridge in Deyu, Guizhou



(a)



(b)

Fig. 3 The green construction technology—prefabricated bridge construction (a) The standardized centralized prefabrication of components in the precast factory (b) The on-site hoisting, installation, and connection of prefabricated components

(2) Clarifying key and difficult points of the course, and provide diverse learning resources.

In arranging course content, given the limitations on class hours, it is important to ensure a connection with preceding and parallel courses, avoiding or minimizing the repetition of content, and emphasizing key and difficult points.

Simpler contents can be assigned for self-study, which not only cultivates students' self-learning abilities but also meets the requirement of limited class hours. For example, in the "Concrete Engineering" section, the properties and processing of steel reinforcement and the preparation of concrete overlap with the prerequisite course "Civil Engineering Materials," and therefore do not need to be reiterated. Similarly, certain aspects of "jacks and anchors" in "Prestressed Concrete Engineering" overlap with content in the "Concrete Structures" course and can be omitted. At the same time, to help students master the interdisciplinary knowledge involved in this course, instructors can provide diverse learning resources for students to explore and learn independently. These resources can include MOOCs, video lectures, virtual laboratories, technical literature, and other materials to help students broaden their horizons and gain a deeper understanding of the course content. Additionally, students can use academic websites such as CNKI, Wanfang Data, VIP Journal, Baidu Scholar, and Google Scholar to learn and explore interdisciplinary knowledge.

3.2 Improving classroom teaching methods to enhance the teaching outcomes

The current teaching methods are often characterized by a single, injection-style approach, where the teacher predominantly lectures while students passively listen. The teacher provides the solutions, methods, and answers to all problems, and with that, the teaching process concludes. This long duration of lecturing results in a lack of interactive communication between the teacher and students, leaving little room for students to think independently. The classroom atmosphere becomes dull, and students may become disengaged, with some even choosing to stop listening due to the overwhelming amount of information, leading to poor teaching outcomes. To address this, it is crucial to shift away from the "spoon-feeding" method in theoretical teaching and adopt more "open-ended" teaching approaches. This requires respecting the students' role as the central focus of the learning process, guiding them to think critically, and encouraging exploration and innovation. Ultimately, this approach aims to establish a learning environment where student learning takes precedence, with teaching serving as a supportive function. The specific measures are as follows:

(1) Introducing digital teaching tools to adapt to educational technology development.

Virtual Reality (VR) technology can create a fully immersive virtual construction environment, allowing students to experience every stage of the construction process, such as foundation construction and structural installation, as if they were physically present [9]. Augmented Reality (AR) technology, on the other hand, can overlay virtual information onto the real-world environment, enhancing the sense of reality [10,11]. Students can interact with elements in the virtual environment using VR and AR devices, such as operating virtual machinery and conducting construction simulations. This interactivity helps deepen students' understanding of construction principles and methods. Through the use of VR and AR technologies, complex construction principles and methods can be intuitively demonstrated, such as structural force analysis and the visualization of construction processes. This aids students in grasping abstract concepts more easily, enhancing their learning experience and outcomes. Additionally, it helps address the limitations of practice bases and experimental facilities by providing a simulated environment where students can practice and experiment.

(2) Implementing the "Flipped Classroom" model to enhance learning proactivity.

Compared to traditional teaching models, the "Flipped Classroom" model is characterized by a role reversal of in-class and out-of-class learning activities. In a "Flipped Classroom", teachers provide theoretical knowledge to students in advance through online videos, reading materials, and other resources, with the knowledge transmission process occurring outside the classroom. The time spent in the classroom is then primarily used for discussions, problem-solving, case analysis, and practical activities, allowing students to consolidate what they have learned [12]. In this teaching model, the teacher acts more as a facilitator and guide during class, helping students address any challenges they encountered during their independent study. Students, on the other hand, can learn at their own pace according to their individual needs and learning progress, offering more space for autonomous learning. This approach better accommodates the diverse learning differences and needs of students, allowing for a more personalized and effective learning experience.

(3) Employing case-based teaching to cultivate innovative thinking.

Teaching with representative and typical construction project cases can effectively improve students' abilities to understand and apply course content [13]. The cases used should encompass the major construction methods and techniques covered in the course, and they should possess a certain level of complexity and challenge. These cases can be drawn from real engineering projects, such as bridge construction or high-rise building construction (as shown in Figure 4). Additionally, engineers or experts who have been directly involved in these case projects can be invited to the classroom to share their practical experiences and insights. The real-world experiences shared by these experts

provide valuable learning resources for students, helping them better understand the application of theoretical knowledge in actual engineering practice. Students can discuss innovative methods and ideas with the experts and use tools such as brainstorming and TRIZ [14] to propose their own insights and improvement plans, thereby training their innovative thinking skills. The main concepts, advantages, and implementation steps of the TRIZ innovation method are illustrated in Figure 5.



Fig. 4 Typical engineering case (a) The Hong Kong-Zhuhai-Macao Bridge in China (b) The Burj Khalifa in Dubai

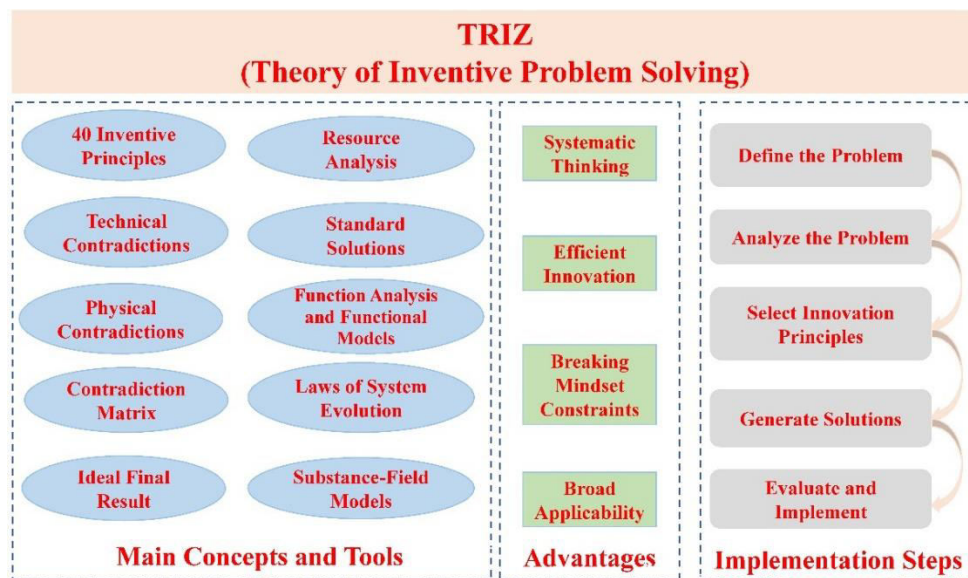


Fig. 5 The main concepts, advantages and implementation steps of the TRIZ

3.3 Emphasizing the integration of theory and practice to cultivate students' innovative abilities

In the teaching process of the "Principles and Methods of Construction" course, instructors need to use scientific methods to cultivate students' innovation awareness and innovative thinking. It is essential to develop students' ability to participate in engineering practice and to comprehensively apply interdisciplinary knowledge to solve problems in production practice, thereby enhancing their innovation capabilities [15].

(1) Fostering innovation spirit and enhance students' practical skills.

Traditional teaching methods often emphasize the transmission of knowledge while neglecting the cultivation of students' innovative thinking and problem-solving abilities. To foster students' innovative spirit, teaching reforms can

incorporate project-based learning (PBL) and problem-based learning (PBL) approaches. These methods guide students to think and explore in real-world contexts, thereby enhancing their capacity for innovation. As civil engineering is a highly practical discipline, students need to accumulate experience through hands-on activities. To improve students' practical skills, it is essential to increase opportunities for on-site internships and training. By actively participating in the management and technical operations of construction sites, students can gain a deep understanding of actual construction processes and the application of techniques. This hands-on experience not only strengthens their professional knowledge but also enhances their career awareness and sense of responsibility.

(2) Establishing innovation competitions to enhance competitive awareness.

In the course, civil engineering can be integrated with other disciplines, such as architectural design, information technology, and environmental science, to create innovative design or research projects. Examples of such projects include green building design, innovative construction technologies, and intelligent construction. These topics can guide students toward exploratory learning, stimulate their innovative thinking, and encourage them to approach problems from different perspectives. By organizing innovation competitions or exhibitions related to construction, students are given the opportunity to showcase their creativity and project outcomes. The process of competition selection and expert reviews can further ignite students' enthusiasm for innovation, enhancing their competitive awareness and building their confidence.

(3) Promoting University-Industry Collaboration to Enhance Practical Teaching.

The university should continuously expand the number and variety of student internship bases and deepen the scope of collaboration with these bases. While supplying high-quality technical professionals to enterprises, the university should ensure that companies provide thorough preliminary guidance and training for students. The university must also take advantage of students' holiday internships by arranging for every student to be mentored by professional engineering and technical personnel. This allows students to gain firsthand experience with actual construction processes and techniques. Upon returning to school, students should engage in discussions and exchanges about the construction technologies they encountered, further deepening their understanding and mastery of these techniques [16].

3.4 Reforming assessment methods to emphasize student competency

The primary assessment method currently in use is the traditional, singular closed-book exam, with fixed question types such as short answer questions, essay questions, and calculation problems. For course content that requires students to understand process principles, the assessment often involves descriptive questions. This approach has led to the phenomenon of "cramming before the exam and forgetting everything afterward" [17]. Therefore, it is necessary to reform the existing assessment methods and establish a diversified evaluation system to comprehensively assess students' learning outcomes.

(1) Increasing the proportion of practical assessments.

Traditional written exams and final tests often focus on theoretical knowledge. To better reflect students' abilities to apply what they have learned in real-world situations, the proportion of practical assessments should be increased. For example: 1) Project design and report. Students can be grouped to work on the design of an actual engineering project, including developing a construction plan, selecting appropriate techniques, and budgeting costs. The group would then submit a comprehensive project report. This approach helps to cultivate students' comprehensive abilities and teamwork skills. 2) On-site simulation or field visits. Students can be organized to visit construction sites or participate in simulated construction activities. Their ability to analyze and make judgments based on real-world conditions can be assessed through these exercises.

(2) Open-ended questions and case analysis.

Traditional exam questions usually have clear, definitive answers, but the realities of construction are complex and ever-changing. Encouraging students to think innovatively and solve problems is crucial. Here are two approaches: 1) Open-ended questions. Design questions that do not have fixed answers, encouraging students to offer their own insights and solutions. These questions can focus on complex issues in construction or emerging technologies. By tackling these types of questions, students are prompted to think creatively and develop original approaches to problem-solving. 2) Case analysis. Provide real-world engineering cases for students to analyze. They would be required to identify problems within the case, propose improvement plans, or offer innovative suggestions. This method helps to

Volume 13, Issue 8, August 2024**|DOI: 10.15680/IJRSET.2024.1308076|**

cultivate students' abilities to solve practical problems and think critically, bridging the gap between theoretical knowledge and real-world application.

(3) Increasing oral presentation and discussion components.

In the construction process, engineers need to clearly articulate their ideas and effectively communicate with team members. To develop these essential skills in students, the following methods can be implemented: 1) Oral reports and debates. Introducing oral presentation sessions where students are required to explain a particular construction method or technology in detail. After their presentation, they would respond to questions from other students or the instructor, fostering an environment of critical discussion and debate. This not only enhances their communication skills but also deepens their understanding of the subject matter. 2) Group discussions and seminars. scheduling regular group discussions in class, where students can engage in in-depth conversations on a specific topic. Each group would then select a representative to summarize and present their findings to the class. This approach encourages intellectual exchange, promotes critical thinking, and strengthens teamwork and collaboration skills.

(4) Continuous assessment and formative evaluation.

In addition to final exams, incorporating formative evaluations can provide a more comprehensive reflection of students' learning progress and development. This approach includes: 1) Periodic assessments. Conducting several periodic assessments throughout the semester, which can include quizzes, assignments, or project presentations. These assessments encourage students to engage in continuous learning and provide regular feedback on their understanding and progress. 2) Classroom participation. Including classroom participation as a component of the final grade. This encourages students to actively engage in discussions and activities, fostering a more dynamic and interactive learning environment. This method not only assesses students' knowledge but also their enthusiasm and involvement in the learning process.

IV. CONCLUSION

This paper focuses on the "Principles and Methods of Construction" course and proposes specific reform measures in four aspects: optimizing course content, improving classroom teaching methods, enhancing students' practical abilities, and reforming assessment methods. Years of teaching practice have demonstrated that the proposed teaching reforms effectively enhance students' practical skills, innovative spirit, communication and collaboration abilities, and self-confidence, leading to positive teaching outcomes. The content of this study can provide valuable insights and references for civil engineering educators.

FUNDING

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research was funded by the university-level teaching reform project at Hunan City University in China, "Teaching Reform and Innovation of the 'Principles and Methods of Construction' Course" (grant number 34), the Undergraduate Innovation and Entrepreneurship Training Plan Program of Hunan Province, China (grant number S202311527025), the Natural Science Foundation of Hunan Province, China (grant number 2024JJ7077) and the Research Foundation of Education Bureau of Hunan Province, China (grant number 23B0732).

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Volume 13, Issue 8, August 2024**|DOI: 10.15680/IJIRSET.2024.1308076|**

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