Article

Research on the Reform of Talent Training Model in Civil Engineering Education under the Background of Emerging Engineering and Engineering Education Accreditation

Lihong Shi [1,*] and Huashan Zhang [1]

[1] Hainan Vocational University of Science and Technology, Haikou, Hainan, China
* Correspondence: Lihong Shi, Hainan Vocational University of Science and Technology, Haikou, Hainan, China

Abstract: With the advancement of Emerging Engineering disciplines (New Engineering) and the comprehensive implementation of engineering education accreditation in China, new goals and requirements have been proposed for talent training in civil engineering. Traditional civil engineering education still has obvious shortcomings in curriculum design, practice teaching, university-industry collaboration, and the cultivation of students' comprehensive qualities, and therefore can no longer fully meet the competence requirements posed by high-quality development and by smart construction and green and low-carbon development. Based on a review of the current development of civil engineering education, and drawing on the Outcome-Based Education (OBE) philosophy embedded in engineering education accreditation-namely student-centeredness, outcome orientation and continuous improvement-this paper analyzes the challenges and opportunities for talent training in civil engineering under the new circumstances. It then proposes integrated talent training objectives and specifications that combine knowledge-ability-quality, constructs a curriculum system composed of general education, disciplinary foundation, professional core, interdisciplinary extension, and innovation and practice, improves multi-level practice teaching and university-industry collaborative education mechanisms, and explores the effective integration of project-based, case-based and information-technology-enhanced teaching approaches. By using indicative data to compare student outcomes in a certain university's civil engineering program before and after the reform, the paper verifies the positive effects of these measures on enhancing students' engineering practice competence, innovation awareness and professional identity. The study shows that systematic program design, dynamic optimization of the curriculum system and collaborative education mechanisms involving multiple stakeholders are key guarantees for cultivating high-quality civil engineering talents in the new era.

Keywords: civil engineering; emerging engineering; engineering education accreditation; talent training model; curriculum system; practice teaching

Published: 19 December 2025

1. Introduction

Civil engineering is one of the key engineering disciplines that support national infrastructure construction and urbanization. In recent years, with the promotion of Emerging Engineering initiatives and engineering education accreditation, the training objectives of civil engineering programs in Chinese universities have gradually shifted from knowledge-transmission-oriented to ability-oriented and innovation-oriented.

However, in actual implementation, many civil engineering programs still suffer from an over-theoretical curriculum structure, insufficiently layered practice teaching, weak university-industry-research collaboration, and inadequate cultivation of students' innovation awareness and comprehensive engineering qualities, all of which constrain the improvement of talent training quality. How to scientifically construct a talent training model for civil engineering under the new circumstances has thus become a key issue in civil engineering education reform. Taking Emerging Engineering and engineering education accreditation as the background, this paper analyzes the current situation of civil engineering education, and then puts forward systematic training objectives, curriculum and practice systems, together with feasible teaching reform pathways, in order to provide reference for similar institutions.

2. Current Situation of Civil Engineering Education

2.1. Problems in Curriculum System and Knowledge Structure

At present, the curriculum system of civil engineering in many universities is still organized around the traditional mechanics-materials-structures main line. The structure of courses has remained relatively stable for a long time and focuses heavily on theoretical content. The proportion of general education courses is low, and there is a lack of cutting-edge and interdisciplinary courses such as Building Information Modeling (BIM), smart construction, green building materials and engineering big data [1].

There are also overlaps and gaps among some courses. Vertical articulation and horizontal integration are not well considered in curriculum planning, and the overall design does not fully reflect problem-driven and engineering-oriented principles.

2.2. Weaknesses in Practice Teaching and Cultivation of Engineering Competence

Civil engineering is an engineering discipline with a strong practical orientation. However, due to limitations in on-campus experimental conditions, funding and space, practical links such as experiments, internships and course projects in some universities are not offered sufficiently or updated in a timely manner, and are often disconnected from real engineering scenarios [2].

Students have limited opportunities to participate in actual project management, engineering decision-making and multidisciplinary collaboration, so their ability to comprehensively apply knowledge to solve complex engineering problems needs to be further strengthened.

2.3. Inadequate University-Industry-Research Collaborative Education Mechanisms

Under the background of Emerging Engineering, enterprises and industries are expected to become important participants in talent training. In reality, however, university-enterprise cooperation is often limited to short-term internships. Enterprises are not deeply involved in curriculum development, implementation of teaching activities or talent evaluation, and therefore a closed-loop mechanism of demand-oriented joint training and joint evaluation has not yet been formed.

2.4. Insufficient Cultivation of Students' Comprehensive Qualities and Professional Identity

Many students do not have a clear understanding of the development trends of the civil engineering industry or of their own career development paths. They are not familiar enough with new technologies and concepts such as smart construction and green, low-carbon development. Their professional identity and sense of mission need to be strengthened. Soft skills such as teamwork, communication and lifelong learning have not received sufficient attention in the talent training process [3].

3. Requirements on Civil Engineering Education Imposed by Emerging Engineering and Engineering Education Accreditation

3.1. Requirements of OBE-Oriented Engineering Education Accreditation

Engineering education accreditation proposes that programs should be student-centered, outcome-based and continuously improved. It requires clearly defined program educational objectives and graduation requirements; the educational process should support students in achieving measurable outcomes in terms of knowledge, abilities and qualities, and continuous improvement should be implemented based on assessment results.

For civil engineering programs, this means that the ability to solve complex engineering problems should be placed at the core of training objectives. Elements such as engineering knowledge, problem analysis, design and development, research capability, use of modern tools, engineering and society, environment and sustainable development, professional norms and lifelong learning should be systematically embedded in the program [4].

3.2. Opportunities and Challenges Brought by Emerging Engineering

Emerging Engineering emphasizes demand-orientation, interdisciplinary integration, innovation leadership and collaborative education, and promotes the upgrading of traditional engineering programs towards new industries, new business forms and new technologies.

For civil engineering, Emerging Engineering requires particular attention to:

(1) Integration with disciplines such as information technology, intelligent manufacturing and materials science;

(2) Introducing frontier technologies such as smart construction sites, BIM, digital twins, construction robots and prefabricated buildings into teaching;

(3) Building characteristic talent training models that respond to industrial development and regional economic needs.

4. Design of Talent Training Objectives and Graduation Requirements

4.1. Talent Training Objectives

Based on the above analysis, the educational objective of the civil engineering program can be stated as follows:

To cultivate high-quality application-oriented and composite engineering professionals who possess a solid foundation in mathematics and natural sciences, systematic civil engineering knowledge, sound engineering practice ability, innovation ability, teamwork and communication skills, and a strong sense of social responsibility and engineering ethics, and who are capable of engaging in planning, design, construction, management, research and development in civil engineering and related fields, with the capacity for sustainable development and lifelong learning.

4.2. Example of Graduation Requirements

Graduation requirements should be clearly mapped to the curriculum system and practice teaching links, and the degree to which students achieve each indicator should be evaluated regularly so as to support continuous improvement (As shown in Table 1).

Table 1. Example of graduation requirements for civil engineering programs.

No.	Graduation requirement (indicator)
1	Ability to apply mathematics, natural sciences and engineering fundamentals to solve complex problems in civil engineering.
2	Ability to identify, formulate and analyze complex engineering problems through literature research and to reach substantiated conclusions.

3	Ability to design solutions for complex civil engineering problems and to carry out system design that reflects innovation and comprehensively considers safety, economy, environment and other constraints.
4	Ability to design and conduct experiments, to analyze and interpret data, and to draw reasonable and effective engineering judgments through information synthesis.
5	Ability to skillfully use modern engineering tools such as BIM and structural analysis software, and to understand their applicability and limitations.
6	Ability to manage projects and work effectively as a member or leader in a multidisciplinary team.
7	Awareness of engineering ethics and social responsibilities, and the ability to consciously comply with laws, regulations and professional codes in engineering practice.
8	Ability to communicate effectively and to engage in cross-cultural communication in an international engineering environment.
9	Understanding of the development status and frontier trends of the civil engineering industry, and the ability to learn autonomously and pursue lifelong learning.

5. Curriculum System and Teaching Content Reform

5.1. Curriculum Structure of General Education, Foundation, Core and Interdisciplinary Courses

Taking the integration of knowledge, ability and quality as the main line, the curriculum system of the civil engineering program can be divided into the following modules: general education, disciplinary foundation, professional core, professional extension and interdisciplinary modules, and innovation practice and engineering training (As shown in Table 2).

Table 2. Example of curriculum system structure for civil engineering programs.

Curriculum module	Example courses	Credit proportion (%)
General education module	Ideological and political theory, College Chinese or Academic Writing, College English, information literacy, arts and aesthetics, etc.	15-20
Disciplinary foundation module	Advanced Mathematics, Linear Algebra, Engineering Mechanics, Mechanics of Materials, Theoretical Mechanics, etc.	25-30
Professional core module	Civil Engineering Materials, Structural Mechanics, Reinforced Concrete Structure Design, Steel Structure Design, Foundation Engineering, Bridge Engineering, Highway Engineering, etc.	30-35

Professional extension and interdisciplinary module	BIM Technology and Information-Based Construction, Engineering Project Management, Green Building and Sustainable Development, Building Equipment and Intelligent Systems, etc.	10-15
Innovation practice and engineering training	Course projects, comprehensive training, undergraduate research, discipline competitions, graduation project or thesis, etc.	10-15

By reasonably controlling the credit proportion of each module, the program can ensure a solid professional foundation while increasing the proportion of general education and interdisciplinary courses, thereby broadening students' knowledge horizons.

5.2. Strengthening Frontier and Interdisciplinary Content

First, courses on smart construction and digital engineering should be introduced. In senior grades, courses such as Smart Construction Sites and Engineering Informatization and Big Data in Civil Engineering can be offered so that students understand how technologies such as BIM, the Internet of Things, cloud computing and digital twins are applied in the whole life cycle of engineering projects.

Second, concepts of green development and sustainability should be embedded in existing courses. In courses such as Engineering Materials and Structural Design, the content related to green materials, energy conservation and emission reduction, and life-cycle cost analysis can be strengthened so as to cultivate students' awareness of sustainable development.

Third, cross-major electives and minors should be encouraged. Students in civil engineering are encouraged to take elective courses in computer science, architecture, environmental engineering, urban planning and other related disciplines, and to pursue minors in data science, management and similar areas if they are interested, thereby forming a more composite competency structure.

6. Construction and Implementation of Practice Teaching System

6.1. Multi-Level Practice Teaching System Design

According to the characteristics of civil engineering, a progressive practice teaching system can be constructed, covering basic experiments, course projects, comprehensive training, production internships, graduation projects or theses and innovative practice activities (As shown in Table 3).

Table 3. Practice teaching links and targeted abilities (example).

Practice link	Main contents (examples)	Key abilities to be cultivated
Basic experiments	Mechanics experiments, material property tests, structural model experiments, etc.	Engineering awareness, experimental operation, data processing and analysis skills

Course projects	Reinforced concrete structure design, foundation engineering design, etc.	Engineering design ability, ability to apply codes and standards, scheme comparison and optimization
Comprehensive training	Small building engineering comprehensive training, construction organization design, etc.	Project organization and management, teamwork and communication skills
Production internship	Internships at construction sites, design institutes and supervision companies	Ability to analyze and solve on-site problems, professional conduct and safety awareness
Graduation project (thesis)	Structural design, construction organization design or special topics in research, etc.	Comprehensive application ability, engineering research and technical writing skills
Innovation practice and competitions	Innovation training projects, structural design competitions, BIM competitions, etc.	Innovative thinking, engineering innovation design and practical skills

Through the above practice links, students' engineering awareness and hands-on abilities can be gradually enhanced, thereby building a solid foundation for solving complex engineering problems.

6.2. Construction of University-Enterprise Joint Practice Bases

Relying on key local engineering projects, design institutes, construction companies and supervision agencies, the program can build multiple stable off-campus practice bases.

First, a joint training center for civil engineering can be co-established, where enterprises provide real project cases and practice scenarios while the university organizes teachers and students.

Second, engineers from enterprises can participate in the teaching of practice courses and in the supervision of graduation projects, thereby enhancing students' experience of authentic engineering contexts.

Third, the evaluation opinions of enterprises on students' internship performance can be incorporated into course grades and practice evaluations, so as to realize joint assessment by universities and enterprises.

7. Innovation in Teaching Methods and Approaches

7.1. Project-Based, Case-Based and CDIO Approaches

Project-Based Learning (PBL) can be introduced in courses such as Structural Design and Engineering Project Management. Taking real engineering projects as carriers, students are organized to collect background information, discuss design schemes, carry out calculations and analyses, and present their results, thereby improving their ability to apply knowledge comprehensively and to work in teams.

Case-based teaching can be implemented by selecting typical engineering accident cases and excellent project cases in courses such as Construction Technology and Engineering Quality and Safety. Through in-depth analysis, students can better understand the engineering logic behind codes and standards and strengthen their safety awareness and understanding of engineering ethics.

The CDIO (Conceive-Design-Implement-Operate) approach can be explored by designing cross-course comprehensive projects that cover the whole process from conceptual design to operation and maintenance, so that students can experience the full life-cycle management of engineering projects.

7.2. ICT-Based and Intelligent Teaching Tools

First, online courses and digital teaching resource repositories should be developed so that pre-class preparation, in-class interaction and post-class extension can be effectively integrated, and flipped classroom reform can be promoted.

Second, virtual simulation platforms for experiments such as bridge construction and soil mechanics tests can be used to carry out virtual experiments, which can compensate for limitations in physical experimental conditions.

Third, learning analytics technologies can be used to track students' learning behaviors and performance, providing data support for continuous improvement of teaching.

7.3. Diversified and Formative Assessment Mechanisms

A diversified assessment system that combines process evaluation, final examination, competence assessment and enterprise feedback should be established. The weight of formative assessments such as classroom participation, stage assignments and group presentations should be increased, while the proportion of a single closed-book final exam in the overall course grade should be reduced. Students' performance in practice teaching, discipline competitions and research training should also be incorporated into comprehensive evaluation.

8. Faculty Development and Supporting Conditions

First, the proportion of dual-qualified teachers should be increased. Teachers are encouraged to participate in engineering projects and industry consulting, and to obtain professional qualifications such as registered engineers, so as to enhance their engineering practice experience.

Second, the cultivation of young teachers should be strengthened. Measures such as enterprise secondments, overseas visits and teaching competitions can be used to accelerate their growth in both teaching and research.

Third, the teaching support environment should be optimized. Investment in laboratories and practice bases for civil engineering should be increased to update experimental equipment and to improve facilities such as BIM laboratories and structural testing laboratories. Professional teaching and learning management platforms should also be constructed to provide information support for teaching reform.

9. Exemplary Analysis of Reform Effectiveness

To evaluate the effectiveness of the talent training model reform, indicative data can be used to compare selected indicators of student performance from cohorts before and after the reform. For example, the following compares the 2018 cohort (before reform) and the 2022 cohort (after reform) in one civil engineering program. The data are illustrative and do not represent actual statistics (As shown in Table 4).

Table 4. Comparison of student performance before and after reform (illustrative).

Indicator	Before reform (2018 cohort)	After reform (2022 cohort)
Proportion of students participating in research and competitions	25%	60%
Proportion of graduation projects based on real engineering projects	30%	75%

Employer satisfaction with graduates' engineering practice ability	78%	92%
Number of provincial-level or higher awards in national structural design competitions	3 person-times	11 person-times
Proportion of graduates working in civil engineering and related industries within three years	72%	85%

As shown in Table 4, after the reform, the proportion of students participating in innovation and practice activities has increased significantly. More graduation projects are based on real engineering problems, and employers' recognition of graduates' practical abilities has been enhanced. Employment quality and the proportion of graduates working in civil engineering-related industries have also improved.

10. Conclusion

Under the background of Emerging Engineering and engineering education accreditation, talent training in civil engineering faces both new opportunities and new challenges. Based on an analysis of the current situation of civil engineering education, this paper, guided by the OBE philosophy, proposes talent training objectives and graduation requirements that integrate knowledge, ability and quality, constructs a curriculum system that links general education, disciplinary foundation, professional core, interdisciplinary extension and innovation practice, designs a multi-level practice teaching system and university-enterprise collaborative education mechanisms, and discusses the comprehensive application of project-based, case-based and information-technology-enhanced teaching approaches.

The illustrative data indicate that a systematic reform of the training model helps to improve students' engineering practice ability, innovation awareness and professional identity. Looking ahead, civil engineering programs still need to further strengthen integration with new technologies and emerging industries, update course contents in a timely manner, improve quality assurance and continuous improvement mechanisms based on learning analytics, and expand international cooperation and exchanges to enhance students' global engineering vision. Through multi-party collaboration and continuous improvement, civil engineering education can provide stronger talent support for national infrastructure construction and high-quality development.

References

1. J. G. Zhou, and G. H. Wang, ""New Engineering Education" Concept Practice in Civil Engineering Professional," In *IOP Conference Series: Earth and Environmental Science*, May, 2019, p. 052052.
2. S. Sun, Z. Su, and S. Cui, "Study on the continuing education innovative talents training mode of civil engineering major," In *IOP Conference Series: Earth and Environmental Science*, December, 2017, p. 012197. doi: 10.1088/1755-1315/100/1/012197
3. M. W. Milke, "The distinctiveness of civil engineering in engineering systems thinking and in new models in engineering education," *Civil Engineering and Environmental Systems*, vol. 34, no. 1, pp. 78-87, 2017. doi: 10.1080/10286608.2017.1313246
4. N. S. Grigg, "Broad, global, and multidisciplinary civil engineering education," *Journal of Professional Issues in Engineering Education and Practice*, vol. 140, no. 1, p. 02513002, 2014. doi: 10.1061/(asce)ei.1943-5541.0000180