

# Innovation and Practice of Civil Engineering Education under the New Engineering Education Perspective

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**Abstract:** This paper explores the innovation and practice of civil engineering education under the new engineering education context. The article first introduces the background of the new engineering education reform and its impact on civil engineering professional education, then discusses in detail the innovative pathways and practical strategies for civil engineering education under this new trend. The article analyzes the shortcomings of the current education model and proposes a series of innovative teaching methods and practical activities, aiming to improve the comprehensive quality and innovative abilities of civil engineering students. Finally, the effectiveness of these innovative measures is evaluated, and future development directions are proposed.

**Keywords:** New Engineering; Civil Engineering Education; Teaching Innovation; Practical Application; Comprehensive Quality

## 1. Introduction

With the rapid development of society and technology, civil engineering education is facing unprecedented challenges and opportunities. The proposal of the new engineering education concept aims to guide the civil engineering major to adapt to the needs of the new era, cultivating students' comprehensive quality and innovative ability through innovative teaching methods and practical activities. This requires educators to transform traditional teaching concepts and build a more open and interactive learning environment. This paper aims to discuss how to effectively innovate and practice civil engineering education under the new engineering education perspective, in order to cultivate engineering and technical talents that can adapt to future social development.<sup>[1]</sup>

## 2. Innovation in Teaching Methods

### 2.1 Curriculum Restructuring

#### 2.1.1 Introduction of Interdisciplinary Courses

Under the new engineering education context, restructuring the curriculum of civil engineering is particularly crucial. A key aspect of this restructuring is the introduction of interdisciplinary courses. These courses not only include traditional civil engineering knowledge but also integrate aspects of environmental science, information technology, management, and other related fields. For instance, courses combining environmental engineering allow students to gain a deeper understanding of and strategies for environmental issues while mastering civil engineering skills.

The advantage of such course design lies in its ability to expand students' knowledge scope and enhance their ability to solve complex engineering problems. For example, courses integrating information technology, such as GIS and BIM, not only improve students' technical capabilities but also strengthen their practical application abilities in project design and management. Through this multidisciplinary course design, students can establish a close link between theoretical knowledge and practical application, fostering innovative thinking and teamwork skills crucial for the successful implementation of modern engineering projects.<sup>[2]</sup>

In practical implementation, course projects like comprehensive courses on structural analysis and environmental impact assessment can be designed, allowing students to consider both structural safety

and environmental sustainability in solving real engineering problems. Such courses not only enhance students' professional skills but also cultivate their environmental awareness and sense of social responsibility.

### ***2.1.2 Application of Project-Based Learning (PBL)***

Project-Based Learning (PBL) is a student-centered teaching method that fosters learning through actual projects. In civil engineering education, the application of the PBL method is particularly important as it tightly integrates theoretical knowledge with real-world engineering practice. Participating in real or simulated engineering projects, students apply their learned knowledge in practice, enhancing their practical skills while promoting critical thinking and problem-solving abilities.

For example, in a bridge design project, students learn not only how to design a bridge but also consider various factors such as cost, environmental impact, and material selection.<sup>[3]</sup> In this process, the role of teachers transforms into guides and consultants, providing necessary resources and support while encouraging independent learning and teamwork. This learning method allows students to learn and grow in a real or near-real work environment.

Another important aspect of PBL is feedback and assessment. Students' performance in projects should be regularly assessed to ensure the achievement of learning objectives. This assessment is based not only on the quality of the final product but also on teamwork, problem-solving processes, innovative thinking, and more. Through such methods, students learn not only professional knowledge but also key skills necessary for their future careers.

In summary, by introducing interdisciplinary courses and applying Project-Based Learning (PBL), the civil engineering teaching system can be effectively restructured to meet the educational needs of new engineering. This teaching model not only enhances students' professional skills but also stimulates their innovative thinking, laying a solid foundation for their future careers.

## ***2.2 Integration of Technology and Tools***

### ***2.2.1 Application of Digital Technology in Teaching***

The rapid development of digital technology has greatly enriched the teaching methods in civil engineering education. Computer-Aided Design (CAD), 3D modeling, digital simulation, and other technologies have become core components of modern civil engineering. The introduction of these technologies not only deepens students' understanding of complex engineering concepts but also greatly improves the efficiency and accuracy of the design process.

For instance, with BIM (Building Information Modeling) software, students can design and analyze building structures in a virtual environment. This method is not only safe and intuitive but also allows students to explore the impact of different design solutions, thus improving their design capabilities. The application of digital simulation tools is also crucial; with these tools, students can simulate the response of building structures under various conditions (e.g., earthquakes or wind forces), thereby understanding the behavior and performance of structures more comprehensively.<sup>[4]</sup>

Furthermore, the application of new technologies expands students' horizons, such as combining remote sensing technology and drones for large-scale topographic mapping and environmental analysis, which is difficult to achieve in traditional courses. Through such practice, students not only learn how to use advanced technologies but also understand their application value in solving real engineering problems.

### ***2.2.2 Innovative Use of Practical Tools***

In civil engineering education, the modernization of traditional laboratory equipment and the introduction of new experimental devices are also crucial for cultivating students' practical abilities. For example, introducing modular experimental equipment allows students to simulate and analyze the behavior of large-scale engineering structures in smaller-scale experiments, which is very helpful for understanding complex structural mechanics principles.

The application of Virtual Reality (VR) and Augmented Reality (AR) technologies has brought revolutionary changes to civil engineering education. With VR technology, students can immerse themselves in a simulated construction site for construction management and safety training without facing real physical risks. AR technology can overlay virtual information in a real environment, such as

displaying underground pipelines and structural layouts on-site, enhancing students' spatial perception and engineering understanding.

The application of sensor technology and data collection systems in laboratories should not be overlooked either. Through these technologies, students can collect and analyze experimental data, learning how to process and interpret large amounts of information, which is crucial for their future data analysis and decision-making abilities in the engineering field.

Through the application of these advanced digital technologies and practical tools, civil engineering education can provide richer and more efficient learning experiences and greatly enhance students' professional skills and innovative abilities. Such teaching models not only meet the educational needs under the new engineering context but also lay a solid foundation for students' future careers, enabling them to better adapt to societal and industry development needs.

### **3. Strengthening Practical Teaching**

#### ***3.1 Integration of Laboratory and On-Site Practices***

##### ***3.1.1 Innovation in Laboratory Teaching***

Under the new engineering context, the laboratory teaching of civil engineering majors is facing a need for innovation. This innovation involves not only the use of advanced simulation software and experimental equipment but also the integration of new teaching concepts and methods. For example, combining Computer-Aided Design (CAD) and Building Information Modeling (BIM) technologies can create a near-real design and analysis environment in laboratories. This enables students to design, analyze, and optimize civil engineering projects in a simulated environment.<sup>[5]</sup>

Further, laboratory teaching can be enhanced by introducing real-time data analysis and sensor technologies. By simulating the construction process of real engineering projects, students can learn how to collect and analyze data relevant to engineering and understand its application in project management and decision-making. For instance, students can analyze the stress and strain of building materials through data collected by sensors, thereby better understanding the principles of material mechanics.

Additionally, practical activities in laboratories can also include team collaboration in a simulated environment, such as assigning different roles and responsibilities to student teams in a virtual engineering project, simulating the cooperation and communication processes in a real work environment. Through these activities, students can improve not only their technical skills but also cultivate teamwork and leadership abilities.

##### ***3.1.2 Integration of On-Site Construction Practice***

The integration of on-site construction practice is crucial for the education of civil engineering students as it provides a bridge between theoretical knowledge and practical application. Through internships, site visits, or direct collaboration with engineering projects, students can gain valuable hands-on experience that is unattainable in traditional classrooms.

In on-site construction practice, students can directly observe and participate in various stages of engineering projects, from the planning and design phase to construction and project management. This experience not only enables students to apply classroom-learned theories to practical situations but also helps them understand various challenges and problems they may encounter in real engineering projects.

For example, by participating in actual building construction projects, students can learn how to manage the site, monitor project progress, handle emergencies during construction, and effectively communicate with the engineering team and clients. These experiences not only enhance their professional skills but also strengthen their adaptability and problem-solving abilities.<sup>[6]</sup>

On-site practice also provides opportunities for interaction with industry experts. By communicating with experienced engineers and project managers, students can receive real-time feedback and advice, understanding the latest trends and technologies in the industry. This experience is significant for the future career development of students.

In summary, by combining innovative laboratory teaching and the integration of on-site construction practice, civil engineering education can more comprehensively cultivate students' overall

abilities, better preparing them for future professional challenges. This strengthening of practical teaching not only improves students' professional skills but also cultivates their teamwork, leadership, and innovation abilities, laying a solid foundation for their future success in the engineering field.

### ***3.2 Industry-Academia-Research Cooperation Model***

#### ***3.2.1 Cooperative Teaching with Enterprises***

In the field of civil engineering, the industry-academia-research cooperation model is becoming an important trend in higher education. This model brings enterprise resources and expertise into the educational process, providing students with abundant practical opportunities and helping them better understand industry demands and future career directions.

Cooperative teaching often includes lectures by industry experts, internship opportunities, and participation in actual enterprise projects. Lectures by industry experts can provide students with the latest industry knowledge and trends, helping them understand current market demands and future directions. These lectures can also cover various topics such as project management, engineering ethics, and sustainable development, offering students a more comprehensive learning experience.

Internship opportunities are a crucial part of this cooperation model. Students can participate in real engineering projects under the guidance of enterprises, experiencing every aspect of a project from planning to execution. This practical experience not only helps students apply classroom knowledge to actual work but also allows them to directly face challenges and opportunities in the work environment, cultivating their problem-solving abilities.

Additionally, students can participate in course projects developed in collaboration with enterprises. These projects are usually designed around actual engineering problems, requiring students to use their knowledge and skills to find solutions. Through this approach, students not only gain valuable practical experience but also improve their professional abilities under the real-time feedback and guidance of enterprises.

#### ***3.2.2 Application of Research Projects in Teaching***

Research projects also play an important role in civil engineering education. Students can participate in research projects led by teachers or research teams, which often focus on solving actual engineering problems or developing new engineering technologies.

By participating in these research projects, students can deepen their understanding of specific areas and gain practical research experience. For example, students might participate in developing new building materials, learning how to perform material testing and performance evaluation. This experience not only helps students master advanced research methods and technologies but also stimulates their innovative thinking and research interests.

Research projects also provide students with opportunities to cooperate with academics and industry experts. In these projects, students can work alongside teachers, researchers, and industry professionals, engaging in innovative research. This interdisciplinary and cross-sector collaboration not only expands students' knowledge and skills but also helps them build professional networks, greatly benefiting their future career development.

Overall, the industry-academia-research cooperation model greatly enriches the content of civil engineering education and enhances the practicality and relevance of teaching by providing students with real engineering project experiences, opportunities to participate in research projects, and direct communication with industry experts. This model not only helps students deepen their theoretical knowledge and improve their practical skills but also fosters their deep understanding of industry trends and job requirements. Through this close integration of industry, academia, and research, students not only acquire professional knowledge during their studies but also develop the ability to solve real-world problems and innovative thinking.

## **4. Cultivating Comprehensive Student Qualities**

### ***4.1 Fostering Innovative Thinking***

#### ***4.1.1 Innovative Thinking Teaching Methods***

In the context of new engineering education, civil engineering education particularly emphasizes the cultivation of innovative thinking, considering it a key ability for students to adapt to future engineering challenges. To cultivate this ability, teaching methods have shifted from traditional knowledge transmission to encouraging students to actively explore and experiment. This method can be realized through various approaches, such as encouraging students to participate in project design competitions, innovative research projects, and interdisciplinary team collaborations.

In practical teaching, teachers can organize case studies facing real engineering problems, encouraging students to autonomously propose solutions under guidance and assess their feasibility. This not only promotes active learning among students but also exercises their critical thinking and problem-solving abilities. For example, students can be assigned to design a sustainable urban drainage system, requiring them to consider environmental, economic, and social factors, and propose innovative design solutions.

#### ***4.1.2 Enhancing Student Innovation Capabilities***

To enhance students' innovation capabilities, universities can provide various resources and platforms. Innovation laboratories are an essential resource, offering advanced equipment and tools, allowing students to freely experiment with new ideas and technologies. In these labs, students can engage in research on real engineering problems, thereby learning through practice and continuously refining their innovative projects.

Cooperation opportunities with enterprises are also important in promoting students' innovation capabilities. Through collaboration with businesses, students can participate in actual engineering projects, understanding the latest technologies and challenges in the industry. These cooperative projects not only provide students with practical work experience but also a platform to realize their innovative ideas.

Moreover, inviting industry experts and pioneering scientists in innovation fields for lectures and seminars is vital in stimulating students' innovative thinking. These experts can share their experiences and insights, exposing students to the latest technological trends and innovative concepts. For instance, organizing lectures on smart buildings or green building materials can inspire students about the latest developments in these fields, sparking their imagination and innovation for the future of construction.

In summary, civil engineering education under the new engineering paradigm strives to cultivate students' innovation capabilities through innovative teaching methods and providing rich resources and opportunities. This not only lays a solid foundation for students' personal development but also brings more innovative ideas and solutions to the engineering field. Through these efforts, civil engineering education can nurture innovative engineers who are capable of adapting to and leading future engineering challenges.

### ***4.2 Enhancing Professional Skills and Literacy***

#### ***4.2.1 Professional Skill Training***

In civil engineering education, training in professional skills is crucial for students' career development. These skills directly relate to students' future performance in the workplace. Professional skill training covers various aspects, including reading and drawing engineering blueprints, on-site construction management, material testing techniques, and the application of the latest engineering software.

For effective skill training, educational institutions can set up specialized practical courses that simulate real work environments. For instance, students can practice actual measurement and drawing exercises under supervision, using professional software for structural analysis and design simulation. Training in on-site construction management can be conducted through virtual reality technology or site visits, allowing students to understand the operational processes of construction sites. Material testing technique training can be conducted in a laboratory environment, where students can personally perform strength and durability tests of materials.

Moreover, civil engineering education should also emphasize the application training of the latest engineering software, such as BIM and GIS technologies. These technologies are increasingly important in the modern civil engineering field and are crucial for students' career development.

#### 4.2.2 Education in Professional Literacy

In addition to professional skills, the cultivation of professional literacy is also an indispensable part of civil engineering education. This includes education in professional ethics, teamwork, communication skills, and leadership. Through group collaborative projects, role-playing, and internships in cooperation with businesses, students can enhance their technical skills and practice their communication and teamwork abilities in real environments.

For example, through team projects, students can learn how to collaborate in multidisciplinary teams to solve complex engineering problems. In these projects, students need to apply their technical knowledge and practice key professional skills such as communication, coordination, and decision-making. Additionally, the curriculum can include discussions on engineering ethics and social responsibility, emphasizing the importance of professional behavior and cultivating students to become responsible and ethical engineers.

Professional literacy can also be strengthened through activities like mock interviews, resume writing workshops, and career planning guidance. These activities help students prepare for their upcoming professional lives and improve their competitiveness in the job market.

Through comprehensive training in professional skills and literacy, civil engineering education can holistically enhance students' overall qualities, equipping them with not only the necessary professional skills but also excellent professional literacy. This enhancement lays a solid foundation for students' future career and personal development, enabling them to perform excellently in their future work and become outstanding talents in the industry.

### 5. Conclusion

This paper thoroughly examines the implications of the new engineering education paradigm on civil engineering professional education, emphasizing the need for dynamic changes in response to emerging trends. By addressing the shortcomings of the current education model and proposing innovative teaching methods, the paper aims to enhance the quality and foster innovative abilities among civil engineering students. The evaluation of these measures underscores the importance of a responsive and adaptive educational approach. The paper advocates for continuous improvement and adaptation in civil engineering education, envisioning a future where successfully implemented strategies bridge existing gaps, nurturing a generation of engineers equipped with the skills needed for future challenges. The suggested future development directions highlight the ongoing commitment to research and exploration, contributing valuable insights to the evolving discourse on the future of civil engineering education within changing engineering paradigms. Overall, the paper significantly contributes to shaping the trajectory of civil engineering education amid the evolving dynamics of the profession.

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