Exploration of Civil Engineering Teaching Oriented Towards Intelligent Construction

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Abstract. With the adjustment of China's civil engineering industry, the transformation of the economy, and the rise of new engineering technologies, traditional civil engineering development faces significant challenges. The trend of future development is oriented towards intelligent construction. This paper analyzes the issues in traditional civil engineering education, such as the disconnection between theory and practice and the lack of education in intelligent technologies, highlighting the necessity of integrating intelligent construction technology into teaching. To address these issues, corresponding reform suggestions are proposed, including updating course content to incorporate intelligent construction knowledge, strengthening practical teaching, and increasing modern teaching methods. These reform measures can promote the development of civil engineering education towards technological integration and innovation, cultivating students' innovative abilities and their adaptability to the future job market, and delivering well-rounded talents to society who possess comprehensive skills.

Keywords: Intelligent Construction; Civil Engineering; Teaching Reform.

1 Introduction

Over the past few decades, China's civil engineering major has experienced rapid development along with the growth of the industry. However, in recent years, due to adjustments in the real estate market and the transformation of the economic structure, the civil engineering major faces unprecedented challenges. On one hand, as the growth of the real estate industry slows down, students' employment expectations for the civil engineering industry have rapidly declined. On the other hand, the rise of new technologies, such as information technology, artificial intelligence, and robotics, has posed new demands on the traditional civil engineering major. The trend of interdisciplinary integration has become the future development direction. This trend requires civil engineering students not only to maintain their traditional professional skills but also to master new technologies to meet the new demands placed on civil engineers by modern society.

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Therefore, civil engineering education needs to update its teaching content and methods to adapt to the developments of the times. In 2018, the Chinese Ministry of Education began approving higher education institutions to add intelligent construction majors, aiming to form a new type of engineering construction major that combines new generation information technology with the foundation of civil engineering. In 2020, the Ministry of Housing and Urban-Rural Development, along with 13 other departments, jointly issued the "Guiding Opinions on Promoting the Coordinated Development of Intelligent Construction and Building Industrialization," stating the need to vigorously develop a new generation of intelligent construction industry systems driven by digitalization and intelligent upgrading, with the construction industry as the carrier. This system will increase the application of intelligent construction in various stages of engineering construction, achieving an integrated intelligent system for research, design, production processing, construction assembly, and operation. So far, 155 universities across the country have established intelligent construction majors, with the development situation shown in Figure 1. It is evident that the intelligent development of civil engineering has gradually become a consensus among the government and all sectors of society. [1-4].

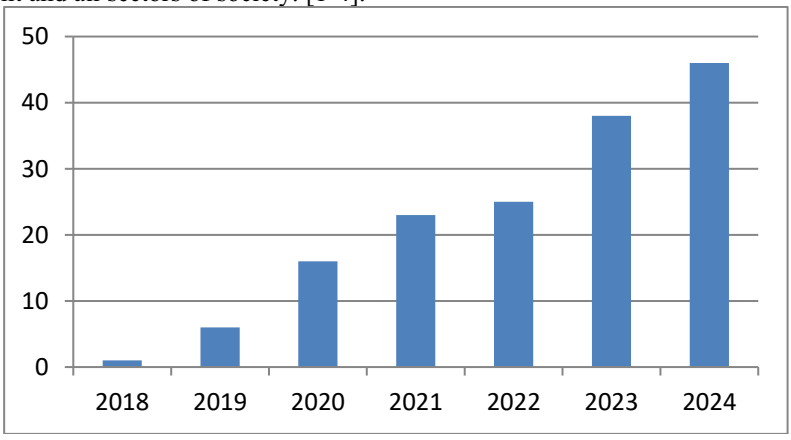

Fig. 1. Statistics on the number of universities in China offering intelligent construction programs

2 Application of Intelligent Construction in Civil Engineering

At present, intelligent construction technology has become an important force driving the progress of civil engineering. Intelligent construction mainly refers to the use of new technological means such as information technology, artificial intelligence, and big data analysis to achieve efficient and intelligent operations in various stages such as architectural design, construction, management, and maintenance[5].

In the design stage, artificial intelligence can optimize architectural design through algorithms and big data analysis, achieving more efficient, environmentally friendly, and economical construction solutions. Through AI algorithms, comprehensive analysis of building materials, structural stability, and energy efficiency can be performed to

achieve optimal design. Utilizing Building Information Modeling (BIM) technology allows for three-dimensional visual simulation, improving the accuracy and feasibility of designs.

In the construction stage, intelligent automated construction equipment can operate in complex or high-risk environments. This not only improves construction efficiency but also reduces safety risks. For example, drones can be used for monitoring and measurement on construction sites, and robotic arms can be used for highly repetitive construction tasks such as concrete pouring and welding.

Additionally, intelligent construction plays a crucial role in engineering management. By utilizing Internet of Things (IoT) technology, real-time monitoring of building materials, equipment, and construction processes can be achieved, effectively enhancing the efficiency and safety of engineering management.

Overall, the application of intelligent construction technology makes the design, construction, and management of civil engineering more efficient, precise, and safe, bringing revolutionary changes to the industry of civil engineering. Therefore, incorporating intelligent construction-related technologies into civil engineering education is an inevitable trend for the future development of civil engineering education[6-8].

3 Current Status and Problem Analysis of Civil Engineering Education

The traditional civil engineering education system has exposed many limitations and inadequacies under the new development circumstances. Here are some of the main problems:

1.Focus on theoretical knowledge over practical engineering skills: The teaching model places heavy emphasis on theoretical knowledge, lacking in the cultivation of practical engineering skills. This leads to a situation where, despite having considerable theoretical knowledge, students often feel at a loss when faced with real engineering problems. Cultivating practical engineering skills is crucial for civil engineering students, including design and construction skills, project management, teamwork, and on-site problem-solving. Without these practical skills, graduates' industry adaptability and career competitiveness are directly affected.

2.Lack of education in intelligent construction technologies: Technologies such as BIM, finite element analysis, and simulation are becoming increasingly important in modern civil engineering. For example, BIM, as a revolutionary tool for engineering design and management, can provide more efficient and precise design solutions, optimizing project management and construction processes. Finite element analysis helps engineers perform more accurate mechanical calculations and structural analyses in structural engineering. Simulation technology can model complex engineering environments and operations, supporting design and decision-making. Learning these intelligent construction technologies can help students adapt to the rapidly developing civil engineering industry. However, the current education system does not cover these topics sufficiently. Only a few schools offer relevant courses at the undergraduate level, and the content is often fragmented and not systematic.

3.Single discipline knowledge is insufficient for future job market demands: With the rapid development of the civil engineering industry and continuous technological advancements, the requirements for civil engineers are increasing. Single-discipline knowledge is no longer sufficient to meet the demand for high-quality engineers in the industry. Future civil engineers need to master not only traditional design and construction knowledge but also have a multidisciplinary background. This includes understanding and applying new intelligent construction technologies, as well as broader skills in project management and data analysis. This raises higher demands on the education system, which must not only impart traditional professional knowledge but also cultivate students' comprehensive qualities and their ability to adapt to the ever-changing job market.

Therefore, it is clear that current civil engineering education needs to reform the traditional teaching model by strengthening the cultivation of practical engineering skills, incorporating new technologies related to intelligent construction, and gradually forming a new civil engineering intelligent construction education system.

4 Recommendations for Civil Engineering Education Reform Focused on Intelligent Construction

4.1 Adjusting the Curriculum System to Integrate Intelligent Technologies

The key reform in intelligent construction is to integrate intelligent technologies into the civil engineering curriculum. Specifically, the following aspects can be considered:

(1) Introduction of Intelligent Design and Analysis Courses: Civil engineering students should learn to use advanced algorithms and computational tools to optimize building designs. For example, by learning to use BIM technology, students can better understand the design and construction process of complex structures through virtual building environments. Additionally, introducing courses related to machine learning and data analysis can enable students to analyze large amounts of construction data, leading to more scientific and effective decision-making. Thus, the curriculum should include training in professional software such as BIM and finite element software, which are essential skills for future engineers.

(2) Practice-Oriented Project Learning: Collaborate with enterprises to provide students with real engineering projects for study and research. This enables students to apply what they have learned and directly experience the application of intelligent construction technologies. For example, students can participate in engineering projects using intelligent sensors and IoT technology, learning how to collect and analyze data to optimize construction processes and improve building energy efficiency.

(3) Encouraging Innovative Thinking: With the continuous emergence of new technologies, students should be encouraged to actively explore new applications of intelligent technology in civil engineering. In teaching, this can be done through intelligent building design competitions, where student teams can think about how to integrate new technologies into traditional civil engineering practices.

These reforms can help build a more modern and practical civil engineering curriculum, advancing the development of civil engineering as students explore and practice new intelligent construction technologies.

4.2 Strengthening Interdisciplinary Teaching Models

For civil engineering education oriented towards intelligent construction, it is essential to actively explore interdisciplinary teaching. This involves breaking down the boundaries between traditional disciplines and integrating knowledge from fields such as computer science, automation technology, and artificial intelligence. This approach provides students with a comprehensive platform for practice and exploration. The introduction of new interdisciplinary experimental courses can be considered. Here are some specific measures:

(1) Course Design Philosophy: Cross-disciplinary experimental courses should be designed around the intersection of civil engineering and emerging technologies. For example, courses can include the application of intelligent materials, the practice of BIM technology, and the use of machine learning for structural analysis. Teaching should encourage students to use interdisciplinary knowledge to solve real engineering problems, fostering innovation and comprehensive skills.

(2) Laboratory Construction: Schools should consider investing in relevant teaching laboratories, including computer hardware, professional software, 3D printers, and robotics engineering kits. These provide the necessary platforms for students to fully engage with new knowledge and technologies in intelligent construction.

(3) Course Content Arrangement: Experimental courses should combine theoretical teaching with practical operations. The theoretical part can be kept as an overview, with the course focusing on helping students deepen their understanding of the theory through practical application. For example, introducing how to use sensors and data analysis software to monitor the health status of building structures while allowing students to design and implement a small intelligent building model.

(4) Interdisciplinary Team Collaboration: Encourage students to form teams with students from other majors such as computer science and mechanical engineering to complete projects together. This helps students understand problems from different perspectives, learn to collaborate, and absorb knowledge from other fields.

(5) Continuous Updating of Course Content: With rapid technological advancements, cross-disciplinary experimental courses need to be continuously updated to ensure that teaching content keeps pace with technological developments. Regularly invite industry experts for lectures and seminars to help students and teachers stay updated on the latest industry trends and technological advancements.

4.3 Modernizing Teaching Methods

Incorporating Modern Teaching Methods into Civil Engineering Education When Possible For example, virtual reality (VR) and augmented reality (AR) technologies can provide a more immersive and interactive learning experience, enhancing the effectiveness and appeal of teaching[9,10]. Specific methods could include:

(1) Introducing VR Technology in Design: Traditional planar design struggles to give students a "real-life" feeling, whereas VR technology can create highly realistic three-dimensional building models, allowing students to experience and analyze their designs in a virtual environment. This improves students' understanding of architectural design and helps them identify potential issues before actual construction.

Application of AR in Construction Teaching: AR technology can overlay computer-generated images onto the real world, providing richer learning content. In civil engineering teaching, AR technology can be used to demonstrate key steps and technical points in the construction process in real-time, such as material properties, construction methods, or safety procedures, thus providing a more direct and in-depth learning experience.

Combining On-Site Internships with Simulation: By combining traditional on-site internships with virtual reality technology, students can be encouraged to further understand complex engineering issues through simulation. This establishes a closer link between theory and practice, enhancing the effectiveness of learning.

By implementing these measures, civil engineering education can be reformed to better equip students with the necessary skills and knowledge for the future.

5 Issues to Avoid in Teaching Reforms

When promoting teaching reforms oriented towards intelligent construction in civil engineering, it is essential to avoid certain issues to ensure the effectiveness of the reforms.

1. Do not weaken the mastery of basic civil engineering theoretical knowledge: Although the application of intelligent technologies in civil engineering is increasingly important, traditional basic civil engineering theories remain the core of professional learning. These foundational theories, such as mechanics, materials science, and structural analysis, are the basis for applying other technologies. Teaching reforms must ensure that students have a solid grasp of these fundamental theories rather than just pursuing the application of new technologies.

2. Clearly define the integration points between intelligent technologies and civil engineering: The teaching should avoid blindly pursuing the application of new technologies without considering the integration points between intelligent technologies and the actual needs of civil engineering. The introduction of intelligent construction technologies aims to improve engineering design efficiency, optimize construction processes, and enhance structural safety. The design of teaching content should be oriented towards practical engineering applications, ensuring that the teaching of intelligent technologies is closely linked to the core needs of civil engineering.

3. Avoid overburdening students; prioritize and make choices wisely: While enriching the curriculum content, teaching reforms should also consider the students' learning burden. A reasonable course design should clarify the primary and secondary relationships of the courses, avoiding the introduction of loosely related courses, to ensure that students can learn comprehensively and in-depth.

6 Conclusions

In the context of rapid technological development and the ever-changing demands of the civil engineering industry, it is imperative to update and improve civil engineering education. By introducing various new intelligent technologies and establishing interdisciplinary courses, new technologies and methods can be effectively integrated into the teaching system, enhancing students' practical abilities and innovative thinking.

Looking to the future, the development of civil engineering education will place greater emphasis on the integration and innovation of technologies. With the continuous application of intelligent technologies in the construction field, future education will focus more on interdisciplinary learning, practical operations, and the cultivation of innovative thinking. This approach will provide students with a broader career development platform and inject new vitality into the development of the entire construction industry.

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