ISSN 1533-9211

DOI: 10.5281/zenodo.13828245

EXPLORATION OF IMMERSIVE CIVIL ENGINEERING COURSE TEACHING MODEL BASED ON VR AND BIM TECHNOLOGIES

Dr. XIA XUEMIN [1]*, SUN YUE [2], PENG CHAOYANG [3] and YANG YUJIE [4]

[1,2,3,4] School of Environment and Architecture, University of Shanghai for Science and Technology, Shanghai, China. Email: [1]xiaxuemin@usst.edu.cn (*Corresponding Author), [2]222271934@st.usst.edu.cn, [3]18239188985@163.com, [4]233432018@st.usst.edu.cn

Abstract

The transformation of the civil engineering industry poses new requirements for talent cultivation. However, there are prominent issues in traditional teaching models, such as a singular teaching format, lack of breakthroughs in practical courses, and unreasonable assessment methods. To address this, it is imperative to integrate BIM and VR technologies into civil engineering education to achieve concretization of teaching content, diversification of teaching formats, and scientific assessment methods. This transformation and innovation in teaching models aim to enhance the quality of talent cultivation and promote the sustainable development of the civil engineering field.

Keywords: Civil Engineering; BIM Technology; VR Technology; Teaching Model.

INTRODUCTION

Currently, China's process of modernization is driving the transformation and upgrading of the traditional construction industry. The "14th Five-Year Plan" outlines the development goals for the digital transformation of the construction industry, calling for exploration of the implementation path for the integration of Building Information Modeling (BIM) with various technologies. Additionally, in-depth innovation in new building industrialization technologies has posed new demands on the development of BIM. Consequently, intelligent technologies such as BIM and Virtual Reality (VR) have become crucial means to facilitate the transformation and upgrading of the construction industry.

BIM technology comprehensively showcases information about physical structures, providing robust information support for design, construction, and management across multiple dimensions and stages, with an emphasis on information integration. VR technology, on the other hand, simulates real environments to offer users a multi-channel, three-dimensional, and near-natural human-computer interactive experience, emphasizing interactive experiences. BIM technology provides data information support for VR technology, while VR technology offers an interactive application platform for the promotion of BIM technology. The organic integration of these two technologies enables virtual roaming throughout the entire construction project implementation process.

Through panoramic displays and multi-role communication interactions, this integration provides efficient technical guidance and management strategies. It promotes the application and development of intelligent technologies in the field of architectural engineering by facilitating virtual exploration of construction projects.

ISSN 1533-9211
DOI: 10.5281/zenodo.13828245

As a traditional engineering discipline, civil engineering is characterized by its complex knowledge structure, strong practicality, and comprehensiveness. Undergraduate students majoring in civil engineering play a crucial role in the field of construction engineering at universities. However, ensuring that their professional competencies match the development of modern intelligent construction technology in China and cultivating composite talents that meet the needs of employers has become a new challenge in current undergraduate education in civil engineering. Traditional singular teaching methods evidently cannot meet the high demands of the rapidly evolving industry for talent. Therefore, timely improvement of the teaching methods for undergraduate courses in civil engineering is of great significance for industry transformation and sustainable development.

This paper summarizes the problems existing in traditional teaching methods for undergraduate courses in civil engineering, analyzes the advantages of the development of BIM and VR technologies in improving teaching methods, and explores the application paths of integrating BIM+VR technologies in undergraduate courses in civil engineering. It aims to provide practical guidance for talent cultivation models in civil engineering under the background of the "New Engineering" paradigm.

1. Issues in the Traditional Teaching Model of Civil Engineering Courses

1.1 Monotony in Teaching Methodology

The traditional teaching model of civil engineering courses primarily emphasizes theoretical education, relying mainly on traditional textbooks and PowerPoint presentations. Teaching is predominantly teacher-centered, with a lack of interactivity. Simultaneously, in the rapidly evolving field of civil engineering, new technologies emerge frequently, while traditional textbook content often lags behind technological innovations. This lag makes it challenging to ensure that students' knowledge remains synchronized with practical engineering practices, leading to a lack of intuitive understanding of engineering operations. For instance, in the context of urban underground engineering construction technology, traditional teaching methods focus on using plan drawings combined with text and multimedia. This approach demands a high level of spatial imagination and comprehension from students, restricting the active engagement of some students in classroom learning. Consequently, this limitation results in low learning efficiency and varying degrees of mastery of the subject matter.

1.2 Insufficient Breakthroughs in Practical Courses

The practical courses in civil engineering encompass both theoretical and hands-on sessions. Typically, these practical sessions involve basic operations and applications of real-world case studies. However, although the cases are derived from actual projects, they are often significantly simplified, leading to a disconnection from real-world problems. Moreover, teaching heavily relies on traditional software tools without integrating them with cutting-edge intelligent technologies. As a result, the depth of instruction is insufficient, hindering students' ability to implement innovative ideas. This lack of integration leads to low engagement and enthusiasm among students, ultimately resulting in unsatisfactory outcomes in practical courses.

1.3 Unreasonable Assessment Methods in Course Evaluation

Traditional assessment methods in civil engineering courses typically include class participation, attendance, assignments, and exams. However, these methods are often too singular, with final exam grades carrying significant weight. This leads some students to engage in last-minute cramming for exams, which fails to accurately reflect their actual understanding of the material.

Traditional exam questions often lack close integration with real-world engineering practice. In actual construction, tasks are carried out based on construction drawings and various standards. However, assessments often do not reflect real-world scenarios, focusing excessively on textbook knowledge. Consequently, students' abilities and practical skills in real engineering scenarios are not adequately evaluated, limiting their understanding of the practical value and professional preparation provided by the course.

2. The Necessity of Integrating BIM+VR Intelligent Technologies

Integrating BIM (Building Information Modeling) and VR (Virtual Reality) technologies is essential due to their complementary strengths and the benefits they offer in various aspects of construction engineering education.

BIM technology utilizes information and data applications throughout the entire lifecycle of construction projects by creating three-dimensional digital models to display key information about architectural products. On the other hand, VR technology serves as the ultimate form of multimedia presentation, integrating multiple sources of information and interaction to create virtual world scenarios through computer simulation. Users can immerse themselves in virtual environments and perceive elements within them.

While BIM technology can convert architectural floor plans into visual multidimensional data models, facilitating information transmission, processing, and sharing, it lags behind VR technology in terms of visual presentation and interactive experience. By integrating VR platforms with BIM models, more accurate simulations of real-world application scenarios in construction projects can be achieved, effectively integrating multiple intelligent technologies and providing reference for the integration and application of intelligent technologies in the construction field.

The integration of BIM and VR intelligent technologies breaks through the limitations of time and space. When introduced into professional course teaching, it transforms traditional teaching modes, deepens students' experience of intelligent technology applications in the field of civil engineering, and promotes classroom interaction between teachers and students. It helps enhance students' real-world perception of professional courses, closely linking physical spaces and environments with construction engineering practice values, vividly presenting them in virtual environments, and stimulating students' exploration desires.

This integration not only attracts students to immerse themselves in professional course practices that incorporate BIM and VR technologies but also provides new technological support for innovative teaching strategies.

ISSN 1533-9211
DOI: 10.5281/zenodo.13828245

3. Refinement of Teaching Application Models for Civil Engineering Courses through the Integration of BIM+VR Intelligent Technologies

3.1 Application in Theoretical Course Teaching

Establishing a digital teaching resource repository based on BIM and VR technologies, encompassing various virtual scenarios including architectural models, construction processes, and equipment operations. Grounded on real engineering cases, the repository employs BIM technology for three-dimensional modeling, followed by interactive demonstrations using VR technology, enabling students to gain a more intuitive understanding of theoretical knowledge in civil engineering. Taking the "Urban Underground Engineering Construction" course as an example, construction techniques and processes are showcased through the integration of BIM and VR technologies. Unlike traditional one-way classroom instruction, students can immerse themselves in a virtual construction environment, engaging in immersive learning experiences. They can utilize BIM models for real-time interaction, autonomously selecting objects for observation and operation, thereby gaining a deeper understanding of key concepts and considerations and enhancing their grasp of theoretical knowledge. While improving teaching methodologies, ensure students' learning efficiency and enthusiasm.

Integrating BIM and VR technologies can also facilitate the timely incorporation of the latest technologies in the field of civil engineering into the repository. This not only allows students to intuitively experience the application methods and advantages of new technologies but also frees them from external environmental and spatial constraints, aligning more closely with the development trend of intelligence in the civil engineering industry.

3.2 Application in Practical Course Teaching

The integration of BIM and VR technologies allows students to engage in practical operations within a virtual environment, offering significant advantages in guiding civil engineering students in practical course learning.

Firstly, it provides a visualization of teaching content. VR technology can transform abstract content from textbooks into concrete representations. For instance, in a three-dimensional environment, variations in soil bearing capacity and settlement under different geological conditions can be simulated, visually demonstrating the impact of geological conditions on buildings. Utilizing BIM and VR technologies, students can engage in practical operations within a virtual environment, deeply experiencing the engineering details showcased by intelligent technology and simulating the use of construction tools, materials, equipment, and the entire process.

Secondly, it expands the forms of teaching. In instructional design, teachers can utilize VR technology to meet teaching objectives when real-world conditions cannot fulfill practical environmental requirements. On one hand, in the traditional course design of civil engineering programs, CAD is typically used to draw architectural floor plans, elevations, and sections. However, errors in drawing require modifications across all drawings, which is time-consuming and lacks visualization. With the support of integrated BIM and VR technologies,

ISSN 1533-9211
DOI: 10.5281/zenodo.13828245

students can construct three-dimensional architectural models in simulated real environments, providing a more intuitive understanding of internal structures and external designs of buildings and enabling quick and flexible modifications, leading to a dual enhancement in design efficiency and quality. On the other hand, in the construction design phase, traditional course design mainly focuses on calculating the quantity of construction materials and determining detailed construction steps, failing to anticipate potential issues during the construction process. Integrating BIM and VR technologies can simulate the entire construction process, identifying potential problems and inspiring students to propose reasonable solutions. While meeting regulatory requirements, students can also implement their innovative ideas through BIM and VR technologies, effectively experiencing the joy of applying knowledge to practice. The integration of BIM and VR technologies in practical course teaching provides students with immersive learning experiences, meeting the needs for situational and natural interactive learning media.

Thirdly, it enhances the scientific nature of assessment methods. In the course assessment process, emphasis should be placed not only on students' mastery of theoretical knowledge and professional skills but also on competency-based assessment using BIM physical models, combined with VR simulated practical teaching, to maximally evaluate students' ability to apply their knowledge.

4. Expected Effects of Integrating BIM and VR Technologies in Civil Engineering Course Teaching

The integration of BIM technology and VR technology in civil engineering course teaching is expected to provide a more comprehensive and realistic learning experience, and also helps students apply advanced technological methods to problem-solving in future work. The anticipated effects of integrating BIM technology and VR technology into traditional civil engineering teaching methods are as follows:

Significant improvement in teaching efficiency and quality: The combination of visual BIM technology and immersive VR technology makes abstract knowledge more tangible, providing students with a vivid engineering site experience. In addition to classroom learning, students can enter virtual environments to study professional knowledge at any time, which helps improve teaching efficiency. The introduction of intelligent technology also enables instructors to assess students' learning outcomes more quickly and accurately, dynamically adjust teaching strategies based on student feedback, further guide students efficiently, and enhance teaching quality.

Substantial enhancement in students' innovative thinking: In classroom teaching incorporating BIM and VR technologies, students actively participate in the learning process. In an open learning environment, connecting theoretical knowledge with practical engineering projects, students can explore design ideas for engineering solutions in more vivid virtual engineering sites. They can independently propose solutions to complex problems, thereby enhancing their ability for independent thinking and innovative exploration.

The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.13828245

Systematic optimization of students' practical abilities: Civil engineering majors require high practical abilities. Through virtual modeling experiments combining VR and BIM technologies, students can engage in activities such as architectural structure design and construction scheme design in simulated environments.

This allows for better integration of theoretical knowledge with practical engineering practice, deepening their understanding of theoretical knowledge, effectively testing practical outcomes, and steadily improving practical abilities.

Substantial growth in competitive advantage in employment: Fully integrating BIM technology and VR technology into professional course teaching not only promotes students' learning of professional knowledge but also enhances their application abilities in BIM technology. The development of the modern intelligent construction industry increasingly requires talents proficient in these technologies. Therefore, the integration of intelligent technologies can create better competitive advantages for students in the job market.

CONCLUSION

BIM technology has tremendous application value in the practical engineering field, while the development of VR technology provides new ideas for innovative teaching methods. The combination of these two technologies will have broad application prospects in the training of undergraduate talents in civil engineering.

Integrating BIM and VR technologies into the teaching process through immersive displays allows students to gain a deeper understanding of professional theoretical knowledge and experience the practical engineering processes more intuitively. This approach enlivens the classroom atmosphere, stimulates students' initiative in learning, emphasizes the cultivation of students' innovative consciousness, and shapes core competitiveness in line with industry demands.

The integrated teaching model of BIM and VR technologies in civil engineering courses needs further promotion in the future. This requires coordination between professional teacher training and the allocation of intelligent technology resources, continuous updating of physical models and simulation environments, and alignment with the technical demands of civil engineering teaching.

The goal is to cultivate high-quality talents with practical abilities and innovative thinking in the field of civil engineering, thus driving the transformation and sustainable development of the civil engineering industry.

Funding details

Shanghai Higher Education Young Teachers Training and Support Program; Ministry of Education's Industry-University-Research Collaborative Education Project "Research on Reform of the Teaching Mode of 'New Construction Technology in Civil Engineering Construction' Course Integrated with Virtual Simulation and Smart Construction Technology" (Number: 220901269304439).

ISSN 1533-9211

DOI: 10.5281/zenodo.13828245

Reference

1) Wu, P. (2021). Exploration of the Application of "Civil Engineering Construction" Course Based on BIM and VR Technology. Education and Teaching Forum, (47), 45-49.

2) Cui, J., & Rao, P. (2023). Exploration of the Construction Path of Intelligent Construction Collaborative Education Base under the Background of New Engineering. Fujian Building Materials, (4), 106-108.

3) Zhao, N., & Li, M. (2022). Exploration of the Path of BIM+VR Intelligent Technology Assisting in Improving the Teaching Quality of Engineering Management Specialty. Real Estate World, (6), 46-48.

4) Jiang, Y. (2022). Exploration of the Application of BIM Technology in Civil Engineering Course Teaching. Western Quality Education, 8(16), 134-137.

5) Lu, H., Bao, W., Ning, B., et al. (2018). Exploration and Practice of BIM and VR Technology in the Reform of Civil Engineering Construction Teaching. Higher Architecture Education, 27(5), 127-131.

6) Wang, Y., & Li, H. (2021). Research on the Reform of Undergraduate Teaching in Civil Engineering Based on "Smart +" Technology—Taking VR Teaching of Prefabricated Buildings as an Example. Contemporary Education Theory and Practice, 13(1), 74-78.

7) Yang, Y., Yao, G., Shen, X., et al. (2020). Construction of Immersive Civil Engineering Construction Courses Based on VR and BIM Technology. Education and Teaching Forum, (7), 248-250.