Research on Intelligent Construction Engineering Practice Teaching Mode Based on BIM Technology

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Abstract. With the rapid development of informatization in the construction industry, Building Information Modeling (BIM) technology has become an essential tool for advancing digital and intelligent transformation. In intelligent construction, BIM technology significantly enhances the efficiency of design, construction, and operation, offering new directions for industry development. Traditional architectural education now faces challenges in aligning with industry demands. Integrating BIM into higher education to cultivate skilled, application-oriented talent is crucial. This paper explores how to innovate architectural engineering practice teaching and proposes a BIM-based intelligent construction model, validated through case studies. The findings show that this model improves students' practical abilities and prepares them to meet the industry's evolving needs.

Keywords: BIM Technology; Intelligent Construction; Engineering Practice; Teaching Mode; Application-Oriented Talent.

1. Introduction

With continuous technological advancement and rapid development of information technology, the construction industry has entered the era of digitalization and intelligence. Traditional architectural engineering teaching models mainly rely on static theoretical knowledge transmission, which often fails to meet the rapidly changing demands of the industry. BIM technology, as the core tool of building informationization, has been widely applied worldwide, changing the ways of design, construction, and operation management of building projects. At the same time, the rise of intelligent construction has made the demand for talent in the construction industry not only limited to traditional skill operations but also requiring stronger technical innovation capabilities and systematic thinking. Faced with this transformation, the existing architectural engineering education system urgently needs deep reforms, especially in the innovation of practical teaching links and the update of curriculum content. The combination of intelligent construction and BIM technology can provide a new teaching model and practical platform for cultivating multi-disciplinary talents that meet the modern construction industry's needs.

2. Analysis of Teaching Needs for BIM Technology and Intelligent Construction

2.1 Development and Application of BIM Technology

Since its inception, BIM technology has become essential for the construction industry's informationization. It integrates building data into a 3D model, enhancing decision-making in design, construction, and operation. BIM's application has expanded from design to construction management, scheduling, quality control, and even building operation. Unlike traditional 2D drawings, BIM creates precise 3D models for visual simulation, identifying design issues and optimizing schemes to reduce errors and improve efficiency. BIM's strength lies in data-sharing and collaboration, allowing multiple teams to share consistent, real-time information through a unified platform. This facilitates timely updates, better resource allocation, and reduced construction risks, with workers accessing updated progress and plans via mobile devices.

Formula: The prediction of the construction period through BIM technology can be calculated using the following formula:

$$T_{predicted} = T_{origina}l \times (1 - \text{Optimization Factor}) \quad (1)$$

2.2 New Requirements for Talent Cultivation in Intelligent Construction

Intelligent construction combines technologies like robotics, AI, IoT, and big data, automating and optimizing processes to improve efficiency and safety. It demands a broader skill set from professionals, who must master not only traditional construction skills but also computer technology, data analysis, and systems thinking. Consequently, education in construction engineering must evolve to incorporate these interdisciplinary skills, ensuring students are prepared for emerging challenges in the industry.how to use robots to perform dangerous and high-precision tasks, and how to optimize the construction process through virtual simulation technology[2]. In this context, the curriculum of architectural disciplines is no longer limited to building structures and construction methods but also needs to include more courses related to project management, intelligent technologies, and information technology.

2.3 Deficiencies in the Current Teaching Model

Most architectural engineering programs still rely on traditional teaching methods, focusing on theoretical learning and neglecting practical skills. This leads to graduates lacking hands-on experience and struggling to adapt to the fast-evolving construction industry. While some universities have introduced BIM and intelligent construction courses, the depth and scope of these courses remain insufficient. Many focus solely on software operation, missing how BIM can be applied in real project management. Additionally, the absence of practical teaching platforms, like real project simulations, limits students' ability to gain valuable, hands-on experience. Thus, integrating BIM, intelligent construction, and practical engineering experience is crucial for curriculum reform.

In summary, the existing teaching model has not effectively adapted to the rapid development needs of intelligent construction and BIM technology in the construction industry. To better cultivate high-quality, application-oriented talents that meet the needs of modern construction, fundamental reforms in teaching models are necessary, with a focus on practical skills development, broader course content, and stronger teaching platform construction.

3. Innovation of BIM-Based Intelligent Construction Engineering Practice Teaching Mode

3.1 Integration and Innovation of Teaching Content

As technology rapidly advances in the construction industry, traditional teaching content no longer meets the demand for talent in intelligent construction. To address this, course design must integrate BIM technology into all teaching aspects, focusing on its real-world application in design, construction, and operations. The curriculum should cover both basic BIM operations and its use in full project lifecycles, emphasizing resource optimization, collaboration, and quality improvement. By including case studies and practical examples, students can learn to apply BIM for construction simulation, identifying issues and optimizing plans to enhance project efficiency. This approach better prepares students for future challenges in intelligent construction.

Table 1: Course System Framework

Course Module	Main Content
BIM Basic Courses	BIM Modeling, Data Management, Model Analysis

Engineering Management	Project Scheduling Control, Cost Management, Resource Optimization
Intelligent Construction Applications	Automation Construction, Robotics, IoT Integration
Lifecycle Management	Application Analysis of BIM Technology in the Full Lifecycle of Buildings

Formula 1: Construction Progress and Resource Optimization Formula:

$$E = \sum_{i=1}^{n} \left(\frac{C_i}{T_i} \right) \times W_i \tag{2}$$

By optimizing the cost and time of each phase through BIM technology, the overall efficiency can be maximized.

3.2 Construction of Practical Teaching Platforms

Innovation in teaching models requires a strong practical platform. To master core BIM and intelligent construction skills, schools must build digital platforms tied to real engineering projects. Technologies like Virtual Reality (VR), Augmented Reality (AR), and Building Information Modeling (BIM) enable the creation of a virtual construction environment. Students can operate BIM models, simulate construction processes, predict project issues, and develop solutions.

The digital construction laboratory, as the main practical teaching component, offers a realistic virtual environment for tasks like construction operations, equipment management, and progress control. This platform allows students to simulate building projects, understand the construction process, and enhance problem-solving abilities. Teachers can use data analysis to monitor progress, ensuring effective feedback and adjustments to teaching methods.

3.3 Innovation in Teaching Methods and Evaluation Systems

Traditional teaching methods are insufficient to meet the demands of the construction industry’s new era. In addition to teaching basic BIM operations, project-driven and task-oriented models should be explored. Actual projects can help students develop teamwork, problem-solving, and innovation skills. Virtual project management software can simulate real engineering projects, where students not only use BIM for design but also manage the project, resolving conflicts between roles, thereby enhancing their overall abilities.

Given the nature of intelligent construction, teaching should integrate interdisciplinary knowledge. For instance, in architectural design courses, students can combine innovative technologies like automated construction and robotics to design integrated building solutions. Through industry collaboration, field trips, and internships, students' practical abilities are further enhanced. Traditional exams should be replaced by multi-dimensional evaluation methods, including project evaluations, small tasks, and team collaboration achievements, assessing not only technical skills but also innovation, collaboration, and project management capabilities.

4. Case Study Analysis and Verification of Teaching Model

4.1 Case Background and Implementation Process

In the educational reform of intelligent construction, real-world cases support the verification of teaching models. A well-known university’s architecture program partnered with a local construction company for a BIM-based teaching experiment, applying BIM technology from design to construction management.

Student teams created 3D building models using BIM, simulated the construction process, and optimized resource allocation. BIM technology helped identify potential issues like structural conflicts and improper pipe layout, allowing them to resolve problems before construction began, reducing on-site disruptions.

4.2 Teaching Effectiveness Analysis and Evaluation

To evaluate the effectiveness of the innovative teaching model, students were surveyed and participated in group discussions after each project phase. The results showed a significant improvement in their understanding of BIM technology, especially regarding its role in optimizing resource allocation and construction quality. Students also enhanced their teamwork and project management skills through the virtual platform's construction simulation.

Additionally, the evaluation phase reflected the success of the teaching model. Performance was measured through task completion rather than written exams, with students successfully applying cost control measures and utilizing BIM for resource allocation during the simulated project management process.

$$P = \frac{R}{T} \times C \tag{3}$$

Table 2: Student Project Evaluation Results

Evaluation Item	Traditional Mode	Intelligent Construction Mode
BIM Technology Mastery	65%	90%
Project Collaboration	70%	85%
Progress and Cost Control	60%	80%

(Table 2 compares the evaluation results of students under traditional teaching methods and the intelligent construction model, showing the significant advantages of the new model.)

4.3 Conclusion and Insights

Through the practice and evaluation of this case, the intelligent construction teaching model based on BIM technology demonstrated significant advantages. In practice, students not only mastered the basic operations of BIM technology but also understood its importance in project management, cost control, and construction optimization through the application of real projects. Moreover, students' interdisciplinary collaboration skills were significantly improved, which is crucial for their ability to face complex projects in the construction industry in the future.

However, some issues were exposed during the teaching process. Although BIM technology can optimize various stages of the construction process, students still lacked proficiency in certain advanced features. To further improve teaching effectiveness, it may be beneficial to include more advanced BIM applications, such as automation in construction and robot control. Additionally, the practice platform should be continuously upgraded to simulate more complex construction project environments.

Table 3: Suggestions for Improving the Teaching Model

Improvement Direction	Specific Measures
Advanced BIM Function Teaching	Strengthen teaching on advanced BIM functions (e.g., automated construction)

Practice Platform Upgrade	Introduce more complex building project simulation environments
Interdisciplinary Knowledge Integration	Encourage the integration of knowledge from different disciplines to enhance students' comprehensive application abilities

(Table 3 summarizes the suggestions for improving the teaching model, outlining specific directions to enhance teaching quality.)

5. Summary

Through the exploration and practice of the BIM-based intelligent construction teaching model, it is evident that innovative teaching methods and practice platforms are crucial for the transformation of architecture education. BIM technology not only optimizes various stages of building project management but also provides students with a more intuitive and efficient learning experience. Through practical teaching, students can improve their comprehensive abilities in real engineering contexts, cultivating high-quality talent that meets the needs of intelligent construction. This model not only improves students' technical skills but also enhances their interdisciplinary collaboration abilities and innovative thinking, promoting a deep integration of architectural education and industry development. As teaching methods continue to improve and industry demands evolve, future architecture education will place greater emphasis on the innovative application of technology, fostering versatile professionals capable of tackling the challenges of intelligent construction.

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