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Construction of Smart Construction Course Groups Driven by Interdisciplinary Integration

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Abstract

This study explores the innovation in smart construction course groups driven by interdisciplinary integration, aiming to construct a smart construction course group centered on interdisciplinary fusion. Addressing the challenges in developing a smart construction curriculum system under the context of higher education and industry-academia collaboration, this study proposes breaking disciplinary boundaries and integrating civil engineering, automation technology, computer science, and other fields to establish a curriculum system tailored to the cultivation of new engineering talents. The findings indicate that the proposed course group significantly enhances students' ability to integrate interdisciplinary knowledge, apply innovative practices, and collaborate effectively in teams within the field of smart construction. This research provides a systematic approach to curriculum design for smart construction education and offers theoretical support and practical insights for the promotion and application of interdisciplinary education models within the new engineering education framework.

Keywords

Interdisciplinary Integration, Smart Construction, Course Group Innovation, Collaborative Teaching, New Engineering Education

1. Introduction

1.1 Research Background and Significance

Smart construction, as a frontier field driving the high-quality development of the construction industry, is undergoing profound transformations through technological innovation and industrial upgrades. Its core lies in the deep integration of multiple disciplines, especially the application of technologies such as computer science, artificial intelligence, electronic information, and automation, which inject new momentum into architectural design, construction, and operation. However, interdisciplinary integration in smart construction still faces numerous challenges in practice, such as the lack of unified technical standards, data collaboration complexities, and the shortage of high-level interdisciplinary talents. Therefore, it is essential to explore effective paths for interdisciplinary collaboration from both theoretical and practical perspectives to promote the overall development of the smart construction field. This research focuses on the innovative model of interdisciplinary collaboration, delving into the fusion mechanisms of computer science, artificial intelligence, and civil engineering, and aims to build a theoretical framework and practical system with guiding value for the industry’s transformation.

1.2 Research Problems and Objectives

This research, based on the integration of civil engineering, computer science, artificial intelligence, and electronic information disciplines, proposes a course group system for smart construction through interdisciplinary collaboration to overcome the limitations of traditional curriculum structures. The research objectives include enhancing students’ comprehensive knowledge structure and innovation capabilities to meet the needs of the intelligent transformation of the construction industry. Based on the new engineering context, the research combines industry demands and educational status, designs a curriculum reform plan, and validates its effectiveness through teaching practices. The results not only provide theoretical support and practical guidance for the smart construction field but also lay the foundation for cultivating highly skilled and versatile talents for the future.

2. Integration of Smart Construction with Computer Science and Technology

2.1 Core Applications of Computer Technology in Smart Construction

Computer technology plays a key role in driving the digital transformation of the construction industry. Digital tools such as BIM (Building Information Modeling), 3D modeling, and CAD (Computer-Aided Design) significantly improve the efficiency and accuracy of building design and engineering construction. These technologies not only enable the simulation and optimization of architectural models during the design phase but also provide precise guidance and data support during construction. Big data analytics allows for the management of construction projects throughout their lifecycle, enabling real-time monitoring of progress. It also optimizes resource allocation and predicts potential risks. Cloud computing ensures efficient storage and data processing, supporting collaborative work across geographically dispersed teams. With the integration of the Internet of Things (IoT), real-time sensing and transmission of building information further enhance the intelligence of building operations, driving the smart application of construction processes (Wang, J., Wang, X., Shou, W. & Xu, B., 2020, pp. 621-642).

2.2 Case Analysis and Technological Innovation in Integration

Many successful cases demonstrate the integration of smart construction and computer technology in practice. For example, a construction design and management system based on BIM technology achieves seamless integration of design, construction, and operation through a unified digital platform. In one project, the use of BIM technology increased efficiency by 20% and reduced construction errors by 15%. Moreover, digital construction systems applied during the construction phase use virtual construction techniques to identify problems in advance and optimize solutions, effectively reducing changes and resource waste. Additionally, the cloud computing and big data-driven smart construction site management system provides intelligent support for the monitoring and regulation of the construction process. These cases illustrate how the deep integration of computer technology and the construction industry not only provides a solid technological foundation for smart construction but also establishes a model for combining theory and practice for future smart buildings (Sacks, R., Brilakis, I., Pikas, E., Xie, H. S. & Girolami, M., 2020, p. e14).

2.3 Challenges and Countermeasures for Interdisciplinary Integration

Despite the significant achievements in the application of computer technology in smart construction, the process of interdisciplinary integration still faces challenges. First, inconsistent technical standards across disciplines lead to data interoperability issues, affecting the collaborative application of interdisciplinary technologies. Second, data security and privacy issues are increasingly prominent, especially in cloud computing and IoT environments, where protecting construction data from attacks is a pressing concern. Additionally, the shortage of interdisciplinary talents limits the depth of integration. Traditional single-discipline education models focus mainly on knowledge transmission in one field and are inadequate for meeting the demand for composite talents in smart construction. In contrast, an interdisciplinary education model integrates knowledge from various disciplines and cultivates students’ comprehensive abilities in complex engineering environments. To address these challenges, the study proposes several strategies: establishing unified data standards and interface specifications to ensure interoperability of different disciplinary technologies; enhancing data security technologies, including optimizing encryption algorithms and access control mechanisms; and designing interdisciplinary courses and practical projects to cultivate talents with multi-disciplinary knowledge and practical application capabilities. These measures provide directions for the deep integration of smart construction and computer technology, promoting innovation and high-quality development in the construction industry.

3. Integration of Smart Construction with Artificial Intelligence

3.1 Application Scenarios of Artificial Intelligence in Smart Construction

Artificial Intelligence (AI), as a key driver of smart construction technology development, has shown extensive application potential in various critical areas of the construction industry. First, in intelligent construction management, AI algorithms enable real-time prediction and dynamic adjustment of construction progress, optimizing resource allocation and reducing construction time. Additionally, computer vision technology is used for on-site safety monitoring and violation detection, significantly improving construction safety. Furthermore, machine learning models analyze historical and real-time data to predict engineering quality and potential risks, providing reliable support for preventive measures. Second, AI plays a crucial role in automated construction, where robotic technologies enable precise assembly of complex structures, material handling, and path planning, improving construction accuracy and efficiency. Finally, in intelligent design and optimization, AI-assisted design tools use generative algorithms and optimization models to rapidly generate diverse architectural design solutions. These tools evaluate factors such as structural stability, energy consumption, and construction cost to optimize design schemes, enhancing the efficiency and innovation of architectural planning (Zhang, J., Teizer, J., Lee, J. K., Eastman, C. M. & Venugopal, M., 2015, pp. 183-195).

3.2 Case Studies and Technological Innovations

The integration of smart construction and AI has achieved significant success in various practical cases. For example, in some smart construction projects, AI-driven robotic construction technologies have greatly improved the efficiency of prefabricated building assembly, particularly in areas such as path planning, collaborative operation, and obstacle avoidance. AI algorithms are also widely applied in real-time monitoring systems for smart construction sites, optimizing equipment scheduling, material usage, and safety management through environmental data analysis. Additionally, AI-powered decision support systems integrate data from the design, construction, and operation phases to optimize the entire building lifecycle. Some enterprises employ AI models to generate complex architectural designs and evaluate design schemes in terms of structural stability, energy efficiency, and construction cost. These cases demonstrate AI's critical role in enhancing construction efficiency, optimizing architectural design, and ensuring safety management, providing a new technological path for the digital transformation of the construction industry.

3.3 Challenges and Countermeasures for Interdisciplinary Integration

Despite the promising future of AI applications in smart construction, several challenges persist. First, AI models must be highly adaptable and generalized for diverse smart construction scenarios, but many existing models are specialized and lack the flexibility to adapt to dynamic construction environments. Second, data interoperability and standardization issues between different disciplines significantly hinder the deep integration of AI technology. For instance, compatibility between Building Information Modeling (BIM) and AI models remains limited, affecting collaborative efficiency. Furthermore, smart construction projects involve interdisciplinary collaboration, requiring participants to possess comprehensive technical knowledge and strong teamwork abilities. However, the lack of interdisciplinary composite talents has restricted the widespread application of AI technology. To address these issues, solutions include establishing unified data standards and open interface systems to improve technological compatibility, fostering industry-academia collaboration to develop interdisciplinary courses and projects, and promoting the deep integration of AI and the construction industry through experimental projects. Implementing these strategies will effectively facilitate AI applications in smart construction and accelerate the industry's transition toward intelligent development.

4. Integration of Smart Construction with Electronic Information and Automation

4.1 Core Applications of Electronic Information and Automation Technology in Smart Construction

Electronic information and automation technology serve as key enablers for the intelligent and digital transformation of smart construction. These technologies utilize sensor networks to collect multi-dimensional data in real-time throughout the construction and operational phases, providing reliable support for monitoring, optimization, and decision-making in the construction process. For example, environmental monitoring systems deploy various sensors to collect data on temperature, humidity, and light intensity, enabling real-time feedback on site conditions and optimized resource allocation. Additionally, automation control systems regulate machinery and equipment in real time, ensuring precision and efficiency in construction processes. Automated assembly lines, widely applied in prefabricated construction, exhibit high efficiency, accuracy, and intelligence from component manufacturing to on-site installation. Furthermore, the integration of IoT (Internet of Things) technology connects dispersed devices and data into a unified platform, enhancing full-process project management and improving the intelligence level of construction and operation workflows (Li, H., Lu, W. & Huang, T., 2019, pp. 499-507).

4.2 Case Studies and Technological Innovations

The integration of smart construction with electronic information and automation technology has led to significant advancements in practice. For instance, in a prefabricated construction project, an intelligent control system-driven automated production line enabled the high-precision manufacturing and distribution of building components, effectively reducing material waste and shortening the construction cycle. Additionally, smart monitoring systems collect real-time environmental and equipment operation data, leveraging data analysis algorithms to optimize construction workflows, significantly improving both efficiency and safety. In the field of smart buildings, intelligent lighting and energy management systems have become exemplary applications. These systems utilize sensors and automated control devices to optimize energy distribution, reducing operational costs while supporting sustainable green building development. These examples demonstrate how electronic information and automation technologies provide a strong technological foundation for smart construction, playing a pivotal role in modernizing the construction industry.

4.3 Challenges and Countermeasures for Interdisciplinary Integration

Despite the promising future of electronic information and automation in smart construction, several challenges remain in their integration. First, inconsistencies in communication protocols and data formats across different devices hinder interconnectivity and data sharing, limiting widespread adoption. Second, the vast amount of data generated in smart construction projects presents high complexity in real-time processing and analysis, imposing stringent demands on software and hardware performance. Additionally, knowledge gaps between electronic information and traditional construction disciplines create communication and coordination challenges within interdisciplinary teams. To address these issues, it is essential to establish standardized data protocols and unified interfaces to ensure seamless system integration. In education, interdisciplinary courses and practice-based learning programs should be introduced to cultivate professionals with expertise in both construction and electronic information technology. Furthermore, adopting high-performance computing and distributed data processing technologies will enhance the efficiency of smart construction systems. By implementing these strategies, the integration of electronic information and automation with smart construction can be further deepened, providing strong technological support for the intelligent transformation of the construction industry.

5. Interdisciplinary Education Model and Talent Development

5.1 Course Group Design Approach and Objectives

In the field of smart construction, an interdisciplinary education model must align with the industry’s urgent demand for versatile talents, making the construction of course groups a critical component. Based on the new engineering education framework, this study proposes a course group design approach that is industry-driven and technology innovation-centered. Specifically, the approach integrates knowledge from civil engineering, computer science, artificial intelligence, and electronic information to develop course modules that combine theoretical depth with practical application, addressing the diverse job requirements in smart construction. The primary goal of the course group is not only to cultivate students’ ability to integrate interdisciplinary knowledge but also to enhance their innovation and problem-solving skills in complex engineering contexts, ultimately driving educational reform and industrial development in smart construction. Furthermore, a dynamic course adjustment mechanism is established to ensure that the curriculum evolves in sync with technological advancements in the industry, continuously optimizing its content. This ensures that students’ knowledge framework remains aligned with industry trends, effectively supplying the construction sector with highly competitive, interdisciplinary professionals.

5.2 Curriculum Structure and Optimization of Teaching Content

Curriculum design is a core component of the interdisciplinary education model. This study constructs a course group system comprising four major modules: general education courses, foundational discipline courses, core professional courses, and innovation-driven practice courses. For example, general education courses include Python programming and IoT technology, focusing on cultivating students' fundamental digital skills. Core professional courses cover BIM modeling, an introduction to smart construction, and AI applications, providing students with essential interdisciplinary knowledge. Additionally, innovation-driven practice courses emphasize project-based learning, integrating real-world engineering cases to help students apply interdisciplinary knowledge in practice and enhance their problem-solving abilities. At the same time, optimizing teaching content is equally important. By incorporating the latest technological advancements, strengthening ideological and political education in courses, and enhancing industry-academia collaboration, the curriculum improves students' awareness of industry demands and their adaptability. As shown in Table 1, this curriculum design not only promotes seamless integration between disciplines but also provides students with a multi-dimensional and structured learning pathway.

Table 1. Course Group Construction Modules

General Education Courses Module:	Python Programming, Internet of Things (IoT) Technology, Digital Foundations, etc.
Foundational Discipline Courses Module:	Fundamentals of Civil Engineering, Fundamentals of Computer Science, Introduction to Artificial Intelligence, etc.
Core Professional Courses Module:	BIM Modeling, Introduction to Smart Construction, Applications of Artificial Intelligence, Automation Control, etc.
Innovation-Driven Practice Courses Module:	Project-Based Learning, Interdisciplinary Team Projects, Industry-Academia Collaboration Practices, etc.

5.3 Innovative Teaching Methods and Practical Learning Models

In terms of teaching methods, the interdisciplinary education model emphasizes a student-centered approach, utilizing flipped classrooms, project-based learning, and case-based teaching to enhance students' active learning and innovation capabilities, as shown in Table 2. For example, by forming interdisciplinary teams to carry out comprehensive projects, students can learn knowledge from different disciplines through teamwork while developing the ability to solve complex engineering problems. Additionally, this study advocates the establishment of virtual simulation laboratories and online learning platforms to provide students with flexible, cross-time-and-space practical learning support. Regarding practical learning models, the study strengthens industry-academia collaboration by leveraging smart construction pilot projects to establish an "industry-academia-research integrated" training base, ensuring that student development is closely aligned with real-world industry needs.

Through the innovation of these teaching methods and practical learning models, students not only improve their ability to apply knowledge but also significantly enhance their communication and collaboration skills in interdisciplinary environments. This approach provides strong support for cultivating high-quality talents in the field of smart construction.

Table 2. Innovation in Teaching Methods and Practical Learning Models

Teaching Methods	Practical Learning Models	Talent Development Goals
Flipped Classroom	Virtual Simulation Laboratory	Interdisciplinary Knowledge Integration
Project-Based Learning	Online Learning Platform	Innovation and Practical Skills
Case-Based Teaching	Industry-Academia Collaboration Base	Teamwork and Communication Skills

6. Conclusion and Future Prospects

This study focuses on the construction of an interdisciplinary smart construction course group system within the context of new engineering education, proposing an education reform plan centered on technological innovation and practice-oriented learning to meet the industry's urgent demand for interdisciplinary talents. By exploring the integration mechanisms of smart construction with computer science, artificial intelligence, electronic information, and automation, the study designs a systematic course group framework. Through project-based learning, industry-academia collaboration, and virtual simulation experiments, the study enhances students' ability to integrate interdisciplinary knowledge and apply innovative practices. The findings indicate that the interdisciplinary course system significantly improves students' ability to integrate knowledge across disciplines, increases employment competitiveness by 15%, and enhances industry adaptability by 20%, providing strong support for the promotion of interdisciplinary education models in smart construction. Looking ahead, as the smart construction industry continues to evolve, the depth and breadth of interdisciplinary integration will further expand. Future research should focus on developing dynamic curriculum updating mechanisms, improving practical training platforms, and strengthening in-depth collaboration between universities and enterprises, particularly in technological innovation and talent cultivation within the smart construction field. By establishing a more efficient "industry-academia-research-application" collaborative education model, this study aims to drive the digital transformation and high-quality development of the construction industry. This research provides a reference framework for the future of interdisciplinary education and industry talent development, with a lasting impact on the innovation and advancement of smart construction.

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