Research on the Impact of BIM-Based Micro-Degree Programs on the Career Development of Construction Engineering Students

Andong Wang*, Ansheng Wu
Shaanxi Railway Institute, Weinan, Shaanxi, China
**Corresponding Author*

Abstract: The construction industry is transitioning from rapid expansion to high-quality development, with graduate employment increasingly drawing public attention. To enhance employability, the Ministry of Education has launched the "Double Thousand" initiative for college students' career development. As a trend in architectural evolution, the Intelligent Construction and New-Type Building Industrialization micro-specialty integrates emerging technologies like BIM, AI, and IoT to cultivate interdisciplinary professionals mastering full-process intelligent manufacturing of prefabricated building components. This study investigates the distinctive features and development of BIM micro-specialties. In civil engineering education practices, we propose an innovative "cross-domain integration" concept combining "Integration of Engineering, Digital, and Equipment Technologies" to address complex challenges. Through open, multidimensional theoretical-practical interactions, this approach transforms traditional engineering disciplines, explores emerging fields via interdisciplinary collaboration, strategically positions talent cultivation for future challenges, and accelerates the development of next-generation engineering professionals.

Keywords: Micro-Profession; BIM Technology; New Building Industrialization; Intelligent Construction

1. Introduction

In recent years, China's higher education has seen continuous expansion in enrollment scale, with the number of college students growing rapidly. Correspondingly, the number of graduates has been rising annually, surpassing 11 million for the first time in 2023 and projected to reach 12.22 million by 2025, with associate degree holders accounting for approximately 47%. This has significantly increased employment pressure. Faced with such challenges, graduates are adopting more diversified career paths. They no longer strictly adhere to traditional "tailored employment" approaches but instead make choices based on personal development and industry trends. To address this, there is growing emphasis on promoting teaching resource sharing and interdisciplinary integration within traditional disciplines, transitioning into fields like intelligent manufacturing and the digital economy, while enhancing graduates' practical skills and hands-on capabilities [1-4].

Building on this foundation, to promote high-quality and full employment for college graduates, address the increasingly prominent supply-demand mismatch, and optimize the alignment between higher education and vocational needs, the Ministry of Education has launched 1,000 "micro-specialties" and 1,000 vocational training courses nationwide, implementing the "Double Thousand" Plan to enhance students' employability. Currently, vocational colleges face challenges in aligning their programs with industry demands, with slow updates to program offerings struggling to keep pace with rapid industrial evolution. Additionally, insufficient depth in school-enterprise collaboration and low corporate engagement in micro-specialty development have resulted in curriculum content disconnecting from actual industry needs, failing to precisely match job requirements [5-8].

As China's construction industry transitions from high-speed development to high-quality development, the production mode of the construction sector is shifting from traditional on-site operation to prefabricated component production and assembly. Meanwhile, BIM technology is driving significant transformations in the traditional construction industry worldwide. The new era applies BIM technology,

AI technology, and IoT technology throughout the entire lifecycle of prefabricated buildings to achieve effective access, transmission, and information sharing of component-related data during design, production, transportation, and construction phases. However, since the application of BIM technology in China remains in its infancy, vocational college curricula across related disciplines fail to equip students with the skills required for diverse job requirements during employment. Therefore, this paper establishes a new micro-specialty in BIM industrialized building component production to meet the digital and intelligent development needs of the construction engineering field. It focuses on cultivating interdisciplinary talents proficient in full-process intelligent production technologies for prefabricated building components, while investigating the impact of this micro-specialty on graduates' career development in the construction industry [9-12].

2. Micro-Professional Characteristics Based on BIM Technology

To address the mismatched talent cultivation models, incomplete curriculum systems, and severe scarcity of teaching resources in the construction industry's transition to new business formats, we leverage the "Double Thousand" Plan to conduct research on cultivating high-skilled talents for intelligent construction and new industrialization. Building on BIM technology in civil engineering disciplines, we innovatively propose a "cross-domain integration" concept combining "engineering technology + digital technology + equipment technology" to tackle complex challenges. This approach fosters open, multidimensional interactions between theory and practice, transforms traditional engineering specialties, explores emerging fields through interdisciplinary collaboration, and strategically deploys talent development into future strategic sectors to accelerate the cultivation of new engineering professionals. The new industrialized construction model primarily targets major emerging industries centered on internet and industrial intelligence, including big data, cloud computing, artificial intelligence, blockchain, virtual reality, and smart technologies. BIM-based micro-specialties focus on cutting-edge industries by integrating BIM, AI, IoT, and other emerging technologies, aiming to cultivate professionals who master prefabricated construction techniques while skillfully applying digital intelligence solutions to real-world engineering problems [13-15].

Focusing on the service-oriented construction industry with a core philosophy of collaborative co-construction, shared resources, and joint management, we have established interdisciplinary research teams spanning multiple disciplines, colleges, and organizations. These teams specialize in BIM technology applications, prefabricated construction methods, and robotics maintenance. The establishment of the Smart Construction Industry College has led to the creation of municipal-level technical service platforms, including a Prefabricated Construction Technology Research Center and a Key Laboratory for Ultra-High Performance Materials and Advanced Prefabricated Structures. Practical training bases have been developed for prefabricated construction practices and smart construction management. Students must master the interpretation of prefabricated component construction drawings and core BIM modeling skills to accurately implement design concepts and efficiently create 3D models. They will operate intelligent prefabricated component production lines and smart equipment to ensure efficient manufacturing processes, while mastering intelligent management methods for optimized resource allocation and quality control throughout production. Students must develop structural smart inspection capabilities to guarantee building component safety and reliability, providing solid quality assurance. The program emphasizes cultivating innovative thinking, teamwork, and engineering practice skills to meet the rapidly evolving industry demands.

3. Micro-Professional Training Measures Based on BIM Technology

By integrating theory with practice, the institution leverages its smart factory for architectural training, engineering technology application research center for prefabricated construction, and industry-academia collaboration platforms. Through incorporating cutting-edge industry technologies and real-world project cases, it aligns with educational technology theories and "Internet+" concepts to match the intelligent construction industry chain. This approach establishes theoretical and technical models for teaching resources, integrating AI and IoT technologies into

instruction to implement the educational philosophy of "digitalized construction, intelligent production, smart construction, and intelligent management." The institution fosters collaborative education through industry partnerships, inviting corporate engineers to co-teach with faculty members. These collaborations share career development insights, industry trends, and professional planning advice, helping students clarify career paths while enhancing practical skills and professional competencies. Regular visits to intelligent manufacturing enterprises specializing in prefabricated building components enable students to observe the latest industry technologies and production methodologies. (Figure. 1)

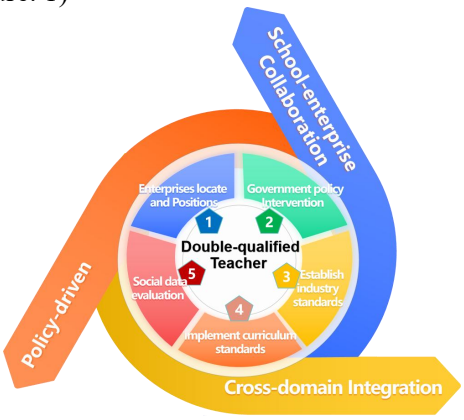

Figure 1. Multi-Party Linkage Optimization Path of Micro-Profession

Focusing on the digital transformation of construction and building processes, this course provides a systematic explanation of the intelligent production management system for prefabricated building components. It covers key technologies such as intelligent production planning and scheduling, digital tracking of materials, collaborative equipment management, and energy efficiency optimization analysis. By integrating big data and cloud computing, it enables full-process visualization and dynamic decision-making in production. Through real enterprise cases and practical training on virtual simulation platforms, students will learn core skills including production planning, intelligent resource allocation, risk early warning, and decision support. The course aims to cultivate students' ability to use digital tools for reducing costs, improving efficiency, and ensuring quality control in component production, thereby supporting the transition toward prefabrication and intelligent transformation.

The curriculum system adopts cutting-edge approaches, focusing on the entire intelligent production process of prefabricated building components. It offers courses covering construction drawing interpretation and modeling, intelligent component production, and management, establishing an integrated knowledge framework of "modeling, production, construction, acceptance". With core features of "industry-academia integration, technology-driven development, and full-chain collaboration", the program closely aligns with industry demands to cultivate versatile technical talents for industrialized construction. The innovative teaching model features deep school-enterprise collaboration: university professors reinforce theoretical foundations while industry experts share practical experience. Courses encompass design standardization, factory production, assembly construction, and digital management, enhancing interdisciplinary collaboration capabilities. The curriculum deeply integrates emerging technologies like BIM, AI, blockchain, and big data, breaking traditional boundaries in road and bridge component manufacturing. This approach achieves organic integration of conventional techniques with intelligent technologies, fostering students' cross-disciplinary application skills.

4. The influence of Micro-specialty Training Based on BIM Technology on Students' Career Development

The industrialization of new construction disciplines addresses the skill gap between micro-specializations and employment competencies, offering fresh perspectives for vocational education supply-side reform. Through analyzing the effectiveness of micro-specialization development in the "Double Thousand Plan", this study provides practical guidance for universities to optimize architectural education models and enhance talent cultivation alignment with market demands. The research helps resolve the structural contradiction of coexisting "employment difficulties" and "labor shortages", providing a basis for government education policy-making and corporate talent development initiatives. Ultimately, it achieves a win-win scenario where graduates secure high-quality employment while industries acquire industry-aligned professionals. The findings demonstrate exemplary value in promoting deep integration between industry and education.

Prefabricated construction and intelligent construction have become the focus of industry upgrading. China started relatively late in the field of prefabricated construction and intelligent construction, with significant gaps in industrial upgrading and an urgent demand for talent. To address this, Shaanxi Province issued the "Implementation Opinions on Promoting the Synergistic Development of Intelligent Construction and New-Type Building Industrialization" in 2021, proposing the goal of prefabricated buildings accounting for over 30% of new constructions by 2025, and prioritizing "strengthening talent cultivation" as a key safeguard measure. Against this backdrop, vocational colleges have actively responded to national and local policies by adjusting their academic programs. Through systematic instruction on core BIM technologies and their applications throughout the building's lifecycle, they aim to cultivate versatile professionals with solid modeling capabilities and diverse application skills, developing high-quality skilled talents that meet the demands of intelligent construction and new-type building industrialization, thereby providing robust support for industry transformation and upgrading.

To achieve talent development goals in intelligent construction and new-type building industrialization, we conducted field investigations and questionnaire surveys at leading enterprises in prefabricated component production and construction. Through on-site exchanges and graduate tracking, we interviewed over 1,200 graduates to compile the "Talent Demand Research Report for Intelligent Construction and New-Type Building Industrialization". This research identified employment positions, job responsibilities, and career transitions among graduates. We established five core professional roles serving the construction assembly sector of the "intelligent construction industry chain": engineering information modeling architecture, quality and safety management of prefabricated components, construction technology management, site quality and safety management, and smart construction site information management. The report formulated a professional training standard emphasizing "production expertise, assembly proficiency, and management competence" for construction assembly fields. Additionally, it developed typical professional competencies including BIM application, intelligent measurement and mapping, smart detection and monitoring, intelligent equipment technology application, intelligent robotics application, and intelligent construction organization. (Figure. 2)

Figure 2. Career Development Direction Under the Micro-professional Training Model

5. Conclusions

At present, prefabricated buildings are in the stage of transformation and rapid development. Vocational education is policy-oriented, micro-profession is the means of implementation, forming a sustainable development chain, building a new driving force for innovation-led development, which is the key to the construction of modern vocational education system, the realization of national revitalization and transformation and the win of development initiative.

1. The integration of BIM and IoT technologies in prefabricated building management optimizes the entire construction process, elevating quality control standards. This approach effectively bridges the gap between traditional vocational education and real-world industry demands, offering innovative solutions for reforming higher education talent development models. The research outcomes demonstrate groundbreaking significance in enhancing graduates' employability and optimizing the structure of vocational education supply.

2. Aligned with vocational education principles and responding to the evolving demands of industrialization, digital transformation, intelligent upgrading, and green development in the construction sector, we will upgrade our construction training base through three key initiatives: optimizing practical training programs, enhancing facility functionalities, and transforming teaching spaces to improve instructional quality. Grounded in industry needs and competency requirements, we will develop specialized theoretical frameworks and technical models for micro-disciplines, while integrating BIM technology, AI solutions, and IoT

applications into our educational resources.

3. Connecting with the cutting-edge industry technologies, we collaborate with various entities such as enterprises and industry associations to deeply integrate advanced industrial technologies into the development of teaching resources. Aligning with the core competencies required for five key job roles, we incorporate new demands from industrial intelligent construction and digital management, and embed modules such as intelligent construction, prefabricated industrialization, and information technology. This approach enables the construction of a multi-dimensional teaching space comprising smart classrooms and physical training bases. By introducing real-world intelligent construction production projects, we implement reforms in integrated interactive teaching models, including modular, blended, flipped classroom, and AI-assisted whole-process learning approaches.

Acknowledgments

This research was financially supported by the Shaanxi Railway Institute of 2025 Education and Teaching Reform Fund Project (No. 2025JG-14).

References

[1] Li Xiaobo. The Ministry of Education implements the "Double Thousand" Plan for Employment Competency Enhancement. Science, Education and Culture Review, 2025(06): 1.

[2] Huang Xia and Zheng Le. Research on the Development Plan for Micro Specialties Guided by Professional Structure Optimization and Adjustment. Innovation and Entrepreneurship Theory: Research and Practice, 2023, 6(18): 89-92.

[3] Zhou Siting. Unlocking the Code of High-quality Employment through the "Double Thousand" Plan. Science and Technology Daily, 2025-04-30 (005).

[4] Jing Xiaoqing. Micro-specialty: Breaking disciplinary Barriers to Promote Talent Training. Science and Technology Daily, 2024-12-04 (005).

[5] Luo Lina, Tang Xiangtao, Wang Lianzheng, et al. "Specialty Development in Vocational Colleges Based on New Requirements of High-Speed Railway Development", Journal of State Radio and Television University, 2019, 19(03): 49-52+109-110.

[6] Wang Ximiao. Exploring the Pathways for Developing Distinctive Specialties in Guangdong's Higher Vocational Colleges: A Case Study of Guangzhou Railway Polytechnic. Journal of Guangzhou Radio and TV University, 2019, 19(03): 49-52+109-110.

[7] Zhang Yun, Xu Qian, and Liu Jia. The Driving Forces, Qualitative Analysis, and Organizational Strategies of Micro Specialization Development in Higher Education. Higher Education Review, 2023, 11(02): 155-166.

[8] CAI Ming. Feasibility Study on the Construction of Micro Specialties in Five-Year Higher Vocational Education. Education Horizon, 2025(07): 72-76.

[9] Huang Jianwei, Xue Peng. Exploring the Construction Path of "Micro Specialties" in Local Applied Universities under the New Liberal Arts Background. China Soft Science, 2024, (S2): 433-438.

[10] Xia Xiaoyun, Chen Zefeng, Zhuang Helin, et al. Research on the Development of the "AI +Smart Transportation" Micro Specialization. Higher Education Journal, 2024, 10(20): 107-110.

[11] Yu Xueli, Zhang Yunhe, Zheng Yuyan, et al. Research on the Construction of Risk Assessment Micro-Specialties Based on the Curriculum System of University Disciplines. Ecological toxicology, 2025, 1-6.

[12] Gao Changping. Research on the Innovation of Interdisciplinary Compound Talent Cultivation Model Based on Micro-Specialties. Anhui Science and Technology News, 2025(012).

[13] Store ShuTing. "small and exquisite" micro professional unlock wide the "new" job way. Newspaper wen wei Po, 2025(001).

[14] Wang Jingjing. Research on the Optimization of the Teaching Staff of the Geriatric Health Care and Management Micro-Specialty under the "Double Thousand" Plan. Modern Vocational Education, 2025, (21):177-180.

[15] Guo Qianwen, Wu Ruoshi, Liu Xiaoyue, et al. Analysis of the Mediating Effect of Professional Identity between Micro-Professional Education and Self-directed Learning of Undergraduate Nursing Students. Health vocational education, the lancet, 2025(15): 138-142.

