

The Current State of Research on the Development of "Dual-Teacher" Teaching Teams for Intelligent Construction under the Background of New Business Models in Architecture

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ABSTRACT: To promote the high-quality development of vocational education and meet the demand for skilled technical talent in the new era, there is an urgent need to build a high-level "dual-teacher" faculty team. The "dual-teacher" teams for intelligent construction face difficulties in areas such as standard development, talent recruitment, training, and incentives, which have become the main factors restricting the construction of high-quality "dual-teacher" teams for intelligent construction in vocational colleges. This paper focuses on the construction of "dual-teacher" teaching teams for intelligent construction in the context of new business models in architecture. By reviewing relevant domestic and international literature, it presents the current status of "dual-teacher" teaching teams for intelligent construction, explores the shortcomings in their development, and proposes corresponding development strategies. This paper aims to provide a reference for the construction of "dual-teacher" teaching teams.

KEYWORDS: Intelligent construction, "dual teacher" teaching team, talent cultivation, new architectural formats

I. INTRODUCTION

Currently, under the guidance of national policies, the entire construction industry is actively promoting the rapid development of intelligent construction. Technological innovations in construction are driving comprehensive changes in the industry, leading to new talent demands and

creating new business models in architecture. The number of "dual-teacher" faculty teams for intelligent construction in China's vocational colleges is severely insufficient, and their overall quality needs significant improvement. These issues hinder the ability to meet the construction industry's demand for high-end technical talent in intelligent construction, and they pose a challenge to effectively supporting the goals of the "Dual-High Plan" (a national plan for high-level vocational education and skilled talent development). The number of "dual-teacher" faculty teams for intelligent construction in China's vocational colleges is severely insufficient, and their overall quality needs significant improvement. These issues hinder the ability to meet the construction industry's demand for high-end technical talent in intelligent construction, and they pose a challenge to effectively supporting the goals of the "Dual-High Plan" (a national plan for high-level vocational education and skilled talent development).

Today, the development of vocational education in China is of great importance. As a crucial part of the national education system, it provides skilled talent and leads socio-economic development. Therefore, improving the quality of talent training in vocational education has become key to social development, and the development of "dual-teacher" teaching teams to train such talent is of paramount importance. To promote the high-quality development of vocational education and meet the market demand for skilled technical talent

in the new era, there is an urgent need to build high-level "dual-teacher" faculty teams

II. INTELLIGENT CONSTRUCTION TECHNOLOGY

(1) Concept of Intelligent Construction Technology

Intelligent construction is an innovative building approach that integrates information technology, artificial intelligence, and engineering construction processes. It includes technologies such as Building Information Modeling (BIM), the Internet of Things (IoT), 3D printing, and artificial intelligence. The essence of intelligent construction is the dynamic configuration of the production process through the integration of design and management, which transforms and upgrades traditional construction methods. The emergence of intelligent construction technologies has accelerated the rapid integration of related technologies. When applied in the construction industry, it makes the processes of design, production, construction, and management more information-driven and intelligent, with intelligent construction leading a new revolution in the construction industry.

(2) Current Status of the Development of Intelligent Construction Technology

The United States and Europe were early adopters of BIM technology, implementing it approximately ten years earlier than other countries. In recent years, countries such as Singapore, Japan, and South Korea have gradually adopted BIM technology, either partially or fully. The Internet of Things (IoT) technology was first proposed in the United States. In 2009, the U.S. identified IoT as one of the six key technologies expected to impact the country by 2025. The development of 3D printing technology in developed countries such as the U.S., Germany, and the UK also began early, with significant financial investments. For example, the U.S. invested \$85 million in 3D printing in 2013, while the European Union invested 160 million euros from 2004 to 2013. In terms of talent education, the U.S. began early reforms and innovations, relying on the market economy to drive change. In 2005, the European Union introduced the "European Digital Competence Framework" standard, initially aimed at defining the competencies required for information and communication technology (ICT) professionals in large European companies. This has since developed into version 3.0 (E-CF3.0), followed by the "eSkills for Jobs 2016" initiative to address the digital talent and skills gap in Europe. Japan's 2009 "i-Japan" initiative emphasized the need to cultivate professionals with high digital competencies. This

was followed by the launch of the "ICT Growth Strategy," "Intelligent Japan ICT Strategy," "Integrated Innovation Strategy," and "Comprehensive Innovation Strategy," a series of plans designed to incorporate university professors and students into the workforce through training and development programs. The development of artificial intelligence, big data, cloud computing, and other technologies in countries like the U.S., the UK, and Germany is at the forefront of global advancements. Government policies, financial investments, technology research and development, and talent training have all supported the growth of intelligent technologies.

Intelligent construction in China is still in its early stages, but under the guidance of national policies, the enthusiasm across the industry is driving its rapid development. The prefabricated construction model supported by BIM technology is a typical feature of intelligent construction. Under the pressure of both internal and external development environments, the transformation of engineering construction toward "greening, informatization, industrialization, and internationalization" has become inevitable [4]. While intelligent construction promotes the rapid development of the construction industry, it also raises higher demands for the skill levels of construction talent. The traditional talent training model for civil engineering students in vocational colleges is struggling to meet the needs of the new business models. High-level "dual-teacher" teaching teams for intelligent construction are key to talent development in vocational colleges.

On July 28, 2020, the Ministry of Housing and Urban-Rural Development, along with thirteen other departments, jointly issued the "Guiding Opinions on Promoting the Collaborative Development of Intelligent Construction and Building Industrialization." The document emphasizes the development of building industrialization as a platform, driving upgrades through digitization and intelligence, fostering innovations in core technologies, and expanding the application of intelligent construction across various stages of engineering projects.

In light of the current development status, we conducted a study on intelligent construction, specifically focusing on the "Digital Transformation of Engineering Construction Enterprises—Intelligent Construction" section. This paper explores the development of intelligent construction technologies both domestically and internationally, aiming to understand the evolving trends of intelligent construction in the building industry.

III. CURRENT STATUS OF THE DEVELOPMENT OF "DUAL-TEACHER" FACULTY TEAMS

Concept of "Dual Teacher" in Intelligent Building Design

(1) "Dual-Teacher" for Intelligent Construction

This study defines a "dual-teacher" for intelligent construction as a professional currently teaching in a school, who has experience working in construction enterprises, participated in intelligent construction projects, and holds relevant vocational qualifications. This individual has rich practical experience and strong practical abilities, capable of integrating theory and practice in teaching and research. In terms of education, they should hold a master's degree or higher and have undergone professional teacher training in vocational education, passing the required assessments. Furthermore, they must possess high moral standards, a strong service-oriented mindset, and excellent psychological resilience.

(2) "Dual-Teacher" Teams for Intelligent Construction

The concept of a "dual-teacher" team for intelligent construction refers to a group of teachers who possess the qualifications or abilities required for intelligent construction, working collaboratively toward a common goal. This team is organized according to specific requirements and structural ratios. The group not only requires that the majority of teachers possess the necessary qualifications and abilities, but also imposes clear requirements on the overall structure of the teaching team.

Current Status of the Development of "Dual-Teacher" Faculty Teams Abroad

(1) The "Vocational Education Teacher Certification System" in the United States

The United States has strict regulations regarding vocational education teacher qualifications, with clear emphasis on the "dual-teacher" qualities. According to these regulations, individuals with a bachelor's degree and 1 to 2 years of practical work experience in a relevant field are eligible to receive a vocational education teacher certification. The general requirements for vocational education teacher qualifications include: teachers must be competent in their teaching duties, generally holding a bachelor's degree in the area they teach, with at least 1 year of practical work experience in the technical courses they instruct. Teachers must also have up-to-date experience in industry, business, or sales, or have more than 5 years of practical experience in the technical field

they teach. These requirements ensure the dual-teacher characteristics in the system.

(2) The "Lifelong Vocational Teacher" System in Germany

In Germany, vocational school teachers must undergo rigorous professional qualification training and vocational education theory courses to gain certification. They are required to receive strict training in professional skills, master the operating procedures of training equipment, and acquire knowledge in vocational education and labor education. For theoretical teachers, an important qualification requirement is to complete at least one year of internship in an enterprise within the same industry as their teaching field. This ensures they understand the organizational structure, production and management methods, and practical operational skills of modern enterprises. After four years of rigorous theoretical study and passing a national exam, teachers must complete a 2-year teaching internship at educational research institutions and vocational schools in various states.

(3) The "Three-Stage Integration" Training System in the United Kingdom

In the United Kingdom, vocational colleges emphasize the development of teachers' practical skills through a three-stage training process: pre-service education, induction guidance, and post-service training. This approach ensures that teaching practice skills and professional competence are developed throughout a teacher's career. Specialized technical teacher training colleges are established to train backup teachers for vocational colleges. In order to gain entry qualifications for vocational institutions, candidates must not only hold a university-level education certificate but also possess a teaching skills certificate and a professional skill level certification.

(4) "Vocational Training Instructors" in Japan

In Japan, "dual-teacher" educators are referred to as "vocational training instructors." They primarily work in vocational high schools, specialized schools, junior colleges, and public vocational training institutions, focusing on the cultivation of skilled professionals. Teachers at vocational colleges and technical schools are required to hold a bachelor's degree from a national industrial university or a comprehensive university's industrial college, and must possess a master's degree to qualify for teaching positions. Japan has established vocational ability development universities responsible for daily training and vocational skills development. These institutions

offer long-term courses (4 years) and short-term courses (6 months). Graduates from vocational ability development universities, upon receiving the national teacher certification, are also eligible to teach at vocational colleges.

IV. CURRENT STATUS OF THE DEVELOPMENT OF "DUAL-TEACHER" FACULTY TEAMS IN CHINA

In the 1980s, the first higher vocational college, Jinling Vocational University, was established. In the practice of running schools, due to the differences in the goals, standards, training processes, and teaching methods between vocational education and general higher education, different requirements were proposed for the quality of vocational teachers. Vocational teachers were required to have two main abilities: the ability to impart knowledge and the ability to guide students' practical work. [1] In 1991, Wang Yicheng first introduced the concept of "dual-teacher" faculty in the article *Efforts to Build a "Dual-Teacher" Faculty*. The article emphasized that building a reasonable "dual-teacher" faculty that closely integrates theory with practice is key to successfully running higher vocational education. [2] Since then, the construction of "dual-teacher" faculty in vocational colleges has become a focus. The successive issuance of relevant policy documents by the government has gradually clarified the concept of "dual-teacher" and the specific requirements for vocational education. An analysis of these policy documents reveals that they have gone through the following three stages.

(1) 1994—1999: Policy-Driven Stage

From the founding of the first higher vocational college to 1985, more than 120 vocational colleges were established with approval from the former Ministry of Education. However, due to the relatively short history, insufficient experience, and lack of attention to higher vocational education in China, along with issues such as mismatched policies, unbalanced development, inadequate teaching conditions, and a lack of distinct program characteristics, most schools ended up offering general associate degrees rather than specialized vocational education. Additionally, the long-standing tendency to "emphasize theory over practice" gradually revealed issues such as insufficient vocational education faculty, an imbalanced structure, and a lack of teachers with professional practice experience.

In 1994, the State Council introduced the "dual-title system for teachers' professional and

technical qualifications" in the "Outline for China's Education Reform and Development." By 1995, the former Ministry of Education issued the "Notice on the Construction of Demonstrative Vocational Universities," which emphasized the need to build a well-structured, competent faculty team, with both full-time and part-time teachers. The notice highlighted the requirement that both professional course instructors and internship supervisors should possess certain practical skills, making "dual-teacher" faculty a key goal for full-time teachers in vocational education. However, the notice did not specify the qualifications or characteristics that teachers must possess to be considered "dual-teacher" educators.

In 1997, the "Opinions on the Establishment of Higher Vocational Schools" issued by the Ministry of Education stipulated that each program in vocational colleges must be staffed with "dual-teacher" educators. In 1998, the Ministry of Education issued the "Principles for Deepening Vocational Education Teaching Reform in the 21st Century," which emphasized the importance of cultivating "dual-teacher" faculty. The policy proposed methods such as "teachers undergoing internships and training in enterprises" or "recruiting teachers with practical experience from enterprises," aiming to ensure that professional course teachers acquire specialized skills. This defined "dual-teachers" as educators who possess both theoretical knowledge and practical teaching capabilities. In 1999, the "Decision on Deepening Educational Reform and Promoting Quality Education" by the Central Committee of the Communist Party of China and the State Council called for accelerating the development of "dual-teacher" faculty who hold both teaching qualifications and other professional technical titles. It emphasized that "dual-teachers" should possess dual identities: that of a qualified educator and a professional in their respective technical fields. However, these policies, while addressing "dual-teacher" educators, only emphasized that teachers should have "practical ability" and "professional skills," without providing clear definitions or standards for the "dual-teacher" concept.

(2) 2000—2004: Clarification of the Concept Stage

In 2000, the Ministry of Education issued the "Notice on Special Research on the Faculty Team in Higher Vocational Colleges," which for the first time clarified the concept of "dual-teacher" faculty and the criteria for recognition. This included practical experience in engineering projects and research and development capabilities in engineering fields. In 2000, the Ministry of

Education issued the "Opinions on Strengthening Talent Development in Higher Vocational Colleges," which stated that "dual-teacher" educators are "both teachers and engineers, accountants, etc.," thus clearly defining the dual identity and dual certification characteristics of "dual-teacher" faculty. In 2002, the "Opinions on Strengthening Faculty Development in Vocational Colleges" issued by the Ministry of Education emphasized the need to establish a faculty team that has "a solid theoretical foundation and strong technical application capabilities," defining the "dual-teacher" qualities of faculty members. The policy called for building the faculty team through multiple channels, including "supporting teachers to participate in industry-academia-research integration and professional practice training," as well as "recruiting senior technical personnel and managers with both practical work experience and solid theoretical foundations from enterprises." Additionally, an incentive mechanism was established to "favor teachers with 'dual-teacher' qualities in promotions and salary increases." In 2004, the Ministry of Education and six other departments issued the "Opinions on Further Strengthening Vocational Education," which called for deepening the concept of "dual-teacher" faculty through measures such as "obtaining relevant professional qualifications" and "evaluating and appointing a second professional technical qualification."

(3) 2005-Present: Institutional Development Stage

In 2005, the State Council issued the "Decision on Vigorously Developing Vocational Education," which called for the establishment of a system in which vocational education teachers must spend two months every two years in enterprises or production/service frontline positions. It also emphasized the implementation of a dual-certification system that includes "second professional technical qualifications" or "relevant vocational qualification certificates."

In 2006, the Ministry of Education issued the "Opinions on Fully Improving the Teaching Quality of Higher Vocational Education," which proposed that "professional teachers be assigned to enterprises for on-the-job practice to accumulate practical work experience and improve their teaching ability." The policy also recommended "recruiting a large number of industry professionals and skilled workers as part-time teachers" and called for the establishment of a "dual-teacher" qualification certification system. It outlined guidelines for teacher appointment standards and entry requirements.

In 2010, the "National Medium- and Long-Term Education Reform and Development Plan (2010-2020)" outlined directions for the development of the vocational college faculty, including "relying on universities and large- and medium-sized enterprises to jointly build 'dual-teacher' teacher training bases," "improving the system for teachers' regular practice in enterprises," "improving relevant personnel management systems," and "increasing the proportion of teachers holding professional technical qualifications and vocational qualification certificates."

In 2011, the Ministry of Education issued the "Opinions on Further Improving the Vocational Education Teacher Training System," which called for the development and improvement of the "continuing education system, regular enterprise practice system, systematic training system, vocational education teacher training practice internship system, and the layout and structure of teacher training bases and the school-enterprise cooperation mechanism for teacher training."

In 2014, the State Council issued the "Decision on Accelerating the Development of Modern Vocational Education," which again emphasized the need to "implement the enterprise practice system for teachers" and "promote the joint construction of 'dual-teacher' teacher training bases by high-level schools and large- and medium-sized enterprises."

In 2016, the Ministry of Education and the Ministry of Finance issued the "Opinions on Implementing the Vocational College Teacher Quality Improvement Program (2017-2020)," which proposed innovative measures such as "promoting school-enterprise co-construction of 'dual-teacher' teacher training bases and enterprise practice bases," "conducting full-cycle teacher training every five years to improve 'dual-teacher' qualities," and "promoting two-way exchange and cooperation between teachers and enterprise staff, establishing a regular mechanism for teachers to practice in enterprises and for enterprise personnel to serve as part-time teachers."

In 2018, the "Opinions on Deepening the Reform of Teacher Team Building in the New Era" was issued, which identified the construction of a high-quality "dual-teacher" faculty and the improvement of vocational college teachers' quality as a key focus. It proposed to "strengthen the construction of vocational and technical teacher colleges, support high-level schools and large- and medium-sized enterprises to jointly build 'dual-teacher' teacher training bases, establish a mechanism for joint training of 'dual-teacher' faculty by higher education institutions and industry

enterprises, promote regular enterprise practice for vocational college teachers to continuously improve their practical teaching abilities, and establish a system of mutual part-time positions for enterprise managers, technical experts, and vocational college administrators and key teachers." Additionally, it emphasized improving teacher assessment and evaluation systems to reflect both skill level and teaching ability, and leveraging school-enterprise cooperation bases to develop high-quality "dual-teacher" faculties to ensure talent development quality.

In September 2019, the Ministry of Education and four other departments issued the "Implementation Plan for Deepening the Reform of 'Dual-Teacher' Faculty Construction in the New Era," and in December 2020, the Ministry of Education and six other departments issued the "Guiding Opinions on Strengthening Teacher Team Construction in the New Era." These documents, in full or in key parts, provide guidance, specific measures, and development goals for the construction of "dual-teacher" faculties. From this, we can see that the development of vocational education is closely linked to the construction of a "dual-teacher" faculty. Especially under the "Double-High Plan" and the goal of building world-class vocational and technical education, we must take measures to resolve the challenges that hinder the development of "dual-teacher" faculty, break through the bottlenecks restricting faculty construction, and strive to create an effective pathway for building a high-quality, professional, and innovative "dual-teacher" faculty with Chinese characteristics.

V. SHORTCOMINGS IN THE CONSTRUCTION OF SMART CONSTRUCTION "DUAL-TEACHER" TEAMS IN CHINA

In summary, both domestic and international research findings indicate that the shortcomings in the construction of smart construction "dual-teacher" teams in China are primarily manifested in the following areas:

There is a lack of detailed and actionable standards for smart construction "dual-teacher" teams. The concept of "dual-teacher" requires a strong theoretical foundation along with a solid practical ability. These educators should be able to integrate rich practical experience into theoretical teaching while also applying theoretical knowledge flexibly to guide practical operations. However, smart construction "dual-teachers" differ from traditional civil engineering "dual-teachers." Smart construction emphasizes the digitalization and

informatization of the construction process but lacks national and local unified standards to guide this transformation. Different educational institutions fail to clearly define the distinction between smart construction "dual-teachers" and traditional civil engineering "dual-teachers," which hinders the cultivation and development of smart construction educators' capabilities. This also makes it difficult to establish a comprehensive and authoritative qualification certification system for smart construction "dual-teachers."

The Supporting Policies for Building Smart Construction "Dual-Teacher" Teams Are Inadequate. The successful development of smart construction "dual-teacher" teams requires a series of robust supporting policies. Compared to traditional civil engineering "dual-teachers," smart construction "dual-teachers" demand higher professional skills, necessitating incentive mechanisms to encourage traditional civil engineering "dual-teachers" and smart construction engineers to transition successfully into smart construction "dual-teachers." Furthermore, policies explicitly support enterprise engineering technicians serving as full-time or part-time teachers in vocational colleges. However, with the limited availability of smart construction technicians, assigning enterprise technical staff—especially high-level smart construction talent—to teaching roles could adversely affect enterprise operations. Moreover, the lack of binding mechanisms for enterprises makes it challenging to foster in-depth talent exchanges and cooperation with vocational colleges.

The Training System for Smart Construction "Dual-Teachers" Is Incomplete. Regarding faculty sources, civil engineering educators in vocational colleges primarily come from recent undergraduate and master's graduates, with only a small proportion holding doctoral degrees. This fails to meet the demand for high-level smart construction educators in vocational colleges. From a vocational training perspective, most recent college graduates lack the ability to guide smart construction professional practice teaching effectively. Pre-service training is typically brief, focusing primarily on theoretical teaching methods, with little emphasis on smart construction-specific training. Once employed, civil engineering teachers face heavy teaching loads, leaving little opportunity for extended off-site training. Training activities are often limited to lectures, forums, and seminars. On one hand, the scarcity of smart construction enterprises results in limited practical training opportunities; on the other hand, enterprises are generally unwilling to engage in deep collaborative training with vocational colleges. Consequently,

teachers' goals of improving their smart construction technical expertise and practical skills through training are difficult to achieve.

vocational colleges and the construction of smart construction "dual-teacher" teams should be proposed.

VI. CONCLUSION AND SUGGESTIONS

(1) BIM technology, 3D printing technology, and IoT technology originated and flourished in Europe and the United States. In parallel, Europe and the United States have made reforms and innovations in talent education, relying on the market economy system to drive changes. China has followed closely behind, strongly supporting the development of smart construction technologies through government policies, financial investment, technological research and development, and talent cultivation.

(2) Ensured their dual-teacher characteristics through systems such as the "vocational technical education teacher certification system," "lifelong professional teachers," and the "three-stage integration" training system.

(3) The series of related policy documents issued by China have gradually clarified the concept of dual-teachers and the specific requirements for dual-teachers in higher vocational education, providing guidance, specific measures, and development goals for the construction of the "dual-teacher" team.

(4) The research reveals that there are still many shortcomings in the construction of China's "dual-teacher" teams, and there is even less research available on the development of smart construction "dual-teacher" teams. Specifically, there is a lack of detailed, actionable standards for identifying smart construction "dual-teachers" and a lack of supporting systems for cultivation, training, and promotion, which severely restricts the development of smart construction "dual-teachers."

In response to the current deficiencies, it is necessary to actively conduct research on the construction of smart construction "dual-teacher" teams and explore new pathways to effectively build high-level smart construction "dual-teacher" teams. The author believes that, first, through investigation and research, an in-depth comparative analysis should be conducted to identify gaps and root causes. By summarizing the advanced experiences of developed countries in cultivating smart construction "dual-teachers" and building related teams, and combining this with China's national conditions, clear standards for identifying smart construction "dual-teachers" in vocational colleges should be formulated. Additionally, incentive measures for smart construction "dual-teachers" should be improved, and a comprehensive cultivation and training system for smart construction "dual-teachers" should be established. Suggestions for the cultivation of "dual-teachers" in

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