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Research on the cultivation model of prefabricated building industrial chain talents ---A case study of intelligent manufacturing technology of prefabricated building components

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Abstract: Under the background of industrial transformation and upgrading, training high-quality technical and skilled personnel matching with the need of industrial enterprises are urgent. However, the research on the training of professional and technical personnel for the prefabricated building model are rarely reported. Adhering to the modern vocational education of OBE philosophy, the mechanism of combining talent cultivation and education training were established based on practical training platforms such as National Virtual Simulation Training Center and Provincial Demonstration Platform for Integration of Industry and Education. The new educational approach for intelligent manufacturing technology of prefabricated building components was explored, and the highly skilled technical talent cultivation for prefabricated construction industry chain was developed, which have been promoting professional development, and successfully raising the standard of talent training. This cultivation model with strong practicality, systematicity and advanced nature has significant reference value for the development of related majors in domestic higher vocational colleges.

Key words: prefabricated building; cmponent production; personnel training; school-enterprise cooperation; transformation and upgrading

1 Introduction

Prefabricated building is a new mode of production and construction, which transfers a large amount of on-site work from traditional construction to the factory, where the construction components and accessories (such as floors, wallboards, stairs, balconies, etc.) are processed and manufactured, transported to the construction site, and assembled through reliable poured concrete or reinforced connections on site [1][2]. Under the background of industrial transformation and upgrading, the State Council and the Ministry of Housing and Urban-Rural Development of China have successively issued more than 10 documents and regulations on the promotion of prefabricated buildings since February 2016. The rise of prefabricated buildings plays a very important role in accelerating the industrial transformation and upgrading of construction enterprises, promoting the green development of industrial structure, and improving the level of architectural technology [3]. In

response to the shortcomings of traditional buildings such as high pollution, high energy consumption and low efficiency, standardized building design, industrial building production and other modern means can be used to speed up the industrialization process, reduce labor input and improve building quality, thus improving building production efficiency and the overall level of building quality [4]. With the implementation of the national strategy of "carbon peak and carbon neutrality", the construction industry is further forced to upgrade towards industrialization and intelligence. Prefabricated modular buildings, as a crucial link in the construction industry, urgently require innovation and application of key technologies in this field. At the same time, talent cultivation and technical skills training must also follow.

2 An overview of the prefabricated construction industry chain and talent demand

The construction industry is a pillar industry of the national economy. However, the production mode is still extensive, and there is still a gap compared with the requirements of high-quality development and the people's yearning for a better life. Especially in the implementation of national strategies such as "carbon peak and carbon neutrality", the construction industry needs to be transformed and upgraded through industrialization and intelligence. In 1999, the General Office of the State Council forwarded *Several Opinions on Promoting the Modernization of the Housing Industry and Improving the Quality of Housing* (1999) No. 72 issued by the Ministry of Construction and other departments, which proposed to promote the intensive and standardized production of residential building materials and parts, and accelerate the development of the housing industry; *Notice of the General Office of the State Council on the Transmission of the Green Building Action Program of the Ministry of Housing and Urban-Rural Development and the Development and Reform Commission* (2013) No. 1 promoted the industrialization of buildings, established a standard system for component design, construction, and production to promote the industrialization of buildings, promote the standardization of structural components and parts, enrich the types of standard parts and improve versatility. Under the background of industrial transformation and upgrading, the State Council and the Ministry of Housing and Urban-Rural Development have successively issued more than ten documents and regulations on the promotion of prefabricated buildings since February 2016, accelerating the industrialization of new buildings, vigorously developing prefabricated buildings, and promoting the green and low-carbon transformation of urban and rural construction, marking that the intelligent construction of prefabricated buildings has risen to the national strategic level. This policy guidance provides a guarantee for the transformation and development of the construction industry [5]. According to the current situation of the construction industry and government policies and measures, the construction industry is facing a huge transformation drive, the proportion of the traditional construction industry will gradually decrease, and the prefabricated construction model will become an important development support object of the current construction model, and will soon become the main force of the development of the construction industry. The industrial chain structure of prefabricated building mode is shown in Figure 1 [6]. The upstream link mainly includes raw material manufacturers, prefabricated component product R&D companies. The representative prefabricated component product R&D companies include Zhongjian Steel Structure Co., Ltd., Beijing New Building Materials Public Limited Company (BNBM), and Beijing Zhuzong Group Co., Ltd. etc. Prefabricated building deepening design is mainly responsible for the overall planning and deepening design of prefabricated buildings. Companies involved in this field, such as China Building Technology Group, Shanghai Modern Architectural Design (Group) Co., Ltd., have a strong competitive advantage in this field. The middlestream link includes prefabricated component production and processing, and the construction of building components, etc. The participants include Broad Residential Engineering, Seiko Steel Structure, Hangxiao Steel structure, Zhuyou Intelligent manufacturing and other prefabricated component production and processing enterprises. There are a large number of prefabricated building construction enterprises, and large enterprises represented by China State Construction Group, Baoye Group, and

Shanghai Construction Engineering Group Co., Ltd. have certain competitive advantages in this field. Downstream is mainly residential and commercial real estate, as well as utility construction.

With the help of modern science and technology to transform traditional industries, artificial manufacturing and artificial construction have been replaced by intelligence, mechanization and automation, so as to improve the level of intelligent manufacturing and intelligent construction [7]. As for the intelligent production, construction and information management of prefabricated buildings, the technical demand, talent demand and security demand in the development of the prefabricated construction industry also increase, which puts forward higher requirements for the technology and quality of construction talents. Traditional construction workers are not competent, and the gap of professional talents of prefabricated buildings is large [8].

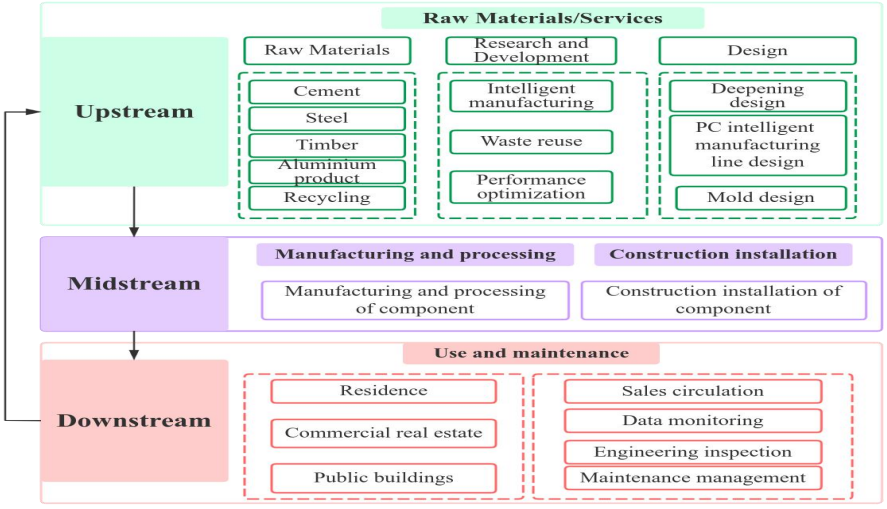

Figure 1. Industrial chain structure of prefabricated buildings

In view of the above situation and needs, the Ministry of Education has added prefabricated building-related majors and some intelligent construction majors in the *Professional Catalog of Vocational Education (2021)*. In the updated list of the vocational education professional directory in 2024, the major of "assembly decoration technology" has been added. This series of "talent + policy" drive not only reflects the deep integration of vocational education and industrial demand, but also injects strong momentum into the transformation and upgrading of the construction industry and the promotion and development of prefabricated buildings.

3 Talent requirements of prefabricated buildings

As the new specialty only published the *Professional Teaching Standard of Higher Vocational Education (Trial Version)*, there is no research on talent cultivation highlighting the characteristics of college. The technical skills of prefabricated construction talents should focus on the prefabricated building industrial chain structure, adhere to the concept of "green, innovation, integration", and conduct green technology research and development, so as to deepen scientific and technological innovation, and activate talent training. With the gradual expansion of the capacity of the prefabricated construction industry, the increasing number of prefabricated construction enterprises, coupled with the strong development of technologies such as the Internet of Things, big data and artificial intelligence, the intelligent integration of new prefabricated buildings, the intelligent design, production and application market of prefabricated building components will continue to expand, and the demand for talents will continue to improve. At the same time, the structure of talent demand in the construction industry will be more inclined to prefabricated technical skills. With the improvement of environmental awareness, factors such as energy conservation, environmental protection, and

sustainability are fully considered in planning, design, and construction to reduce the impact of buildings on the environment.

4 Talent cultivation model and path exploration

4.1 Personnel training specifications

After the Ministry of Education issued the *Catalogue of Vocational Education Majors (2021)*, our institute made a positive response. Based on the characteristics of technical skills training and the requirements of prefabricated construction positions and talents, we determined the training objectives of the intelligent manufacturing technology major of prefabricated building components [9]. By fully utilizing the virtual simulation training base and component production training platform of the college, the concept of "learning by doing, teaching by doing" runs through the entire talent training process, cultivating talents while cultivating morality, and exploring the innovative education mode for professionals in intelligent manufacturing of prefabricated building components.

After multiple revisions, the talent cultivation model for this major has finally been determined to have a total of 20 training standards (indicators), which are divided into three parts: quality index, knowledge index and ability index, as shown in Figure 2. There are 5 quality indicators, 7 knowledge indicators and 8 ability indicators. The courses mainly include public foundation courses and professional (skills) courses. Combined with the feedback from enterprise surveys and the strengths of the college, the teaching content and supporting practical training specifications of the specialized core courses are determined. In addition, aiming at the study of new technologies, techniques, equipment and materials, some professional development courses are also designed and arranged.

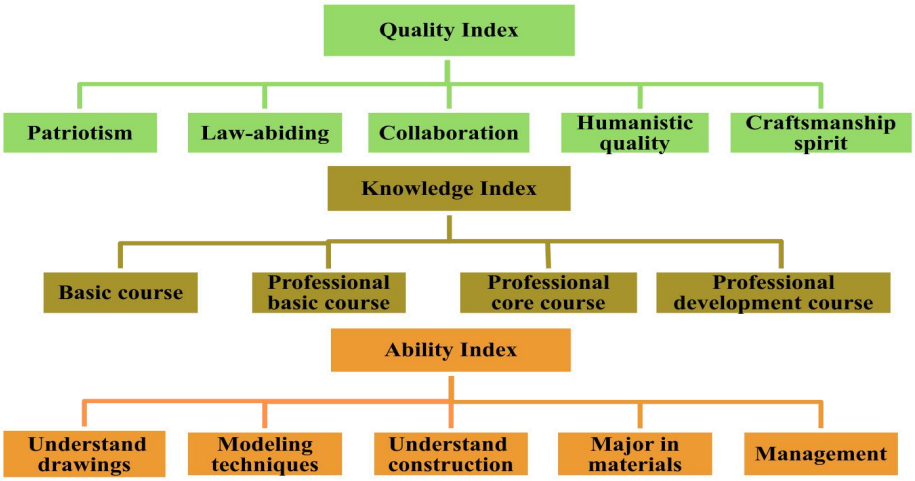

Figure 2. Professional training specifications (indicators)

4.2 Path exploration

An educational team was formed and the training of teachers has been completed. The resource library was established including production and management of prefabricated building concrete components, intelligent tracking and positioning technology of prefabricated building components, and prefabricated building construction technology as the core courses. Meanwhile, an online open courses have been published. Based on the teaching resources, students can learn the course content and measure the achievement of the teaching objectives with the help of assessment and evaluation. Through supporting practical training courses, MOOC learning and other ways, they can further expand the vision of intelligent production of prefabricated building components, strengthen professional literacy and improve the comprehensive quality.

4.2.1 Three-wide education

Adhering to the student-centered teaching, drive-oriented pedagogy as the teaching method, result-oriented as the evaluation standard, the three-stage teaching process of pre-course introduction, in-class implementation, and post-course evaluation was adopted. The course teaching activities are divided into six stages: introducing tasks, exploring new knowledge, studying principles, strengthening skills, evaluating results and expanding skills. The ideological and political themes are timely integrated into the course teaching, promoting knowledge, ability and quality standards to meet the job requirements. The ideological and political elements of the professional curriculum were systematically excavated, making the course levels rich and the system complete. Three-wide education system was carried out through strengthening the teaching team and optimizing the education environment to achieve the integration and unification of ideological and political education and technical skills training for students majoring in intelligent manufacturing technology of prefabricated building components.

4.2.2 Modern information technology

With modern information technology such as "BIM+", big data and artificial intelligence as the carrier, the teaching mode for different course modules in the professional curriculum system of intelligent manufacturing technology of prefabricated building components integrating BIM skills is constructed. The classroom of this major is characterized by diversity. The teaching method adopts "guidance + interaction", and the teaching team corresponds to the students, who makes full use of advanced technologies such as virtual reality and virtual simulation, innovates the practical teaching management system that combines online and offline, virtual and reality, providing a new teaching mode combining ubiquitous teaching, learning and practical training. The teaching place can be changed from classroom to studio, enterprise construction site (production site), etc. Classroom teaching design and time arrangement are divided into the whole and the individual, with the whole teaching completed by the school, and the individual teaching completed by the enterprise and the individual. "Guidance" is the overall grasp aimed at cultivating students' ability to complete (career), while "interaction" is the training of thinking aimed at cultivating students' ability to innovate.

4.2.3 Combining physical and intellectual education

In order to further strengthen labor education, labor teaching must be highlighted. To build a comprehensive labor education system, an overall learning atmosphere of "honorable labor, safe labor and efficient labor" should be created, integrating the core elements and concepts of labor education into the classroom. For practical training courses such as on-the-job practice, graduate field work, etc., labor effectiveness are taken as one of the elements of curriculum assessment. Labour education modules are specially designed. For example, with physical labor mainly based on cement performance testing and mental labor mainly based on classroom activities, physical and mental labor is carried out in the form of group hands-on practice, program discussion etc. The curriculum teaching method attaches equal importance to physical and intellectual strength, integrates knowledge and action, and makes students feel sweaty physical labor and realize labor innovation.

5 Conclusion

Under the background of industrial transformation and upgrading, the high-quality technical and skilled talents matching with industrial enterprises are urgently needed. After sufficient research, intensive design and detailed demonstration, adhering to the OBE modern vocational education, guided by professional teaching standards and supported by practical teaching conditions, and based on practical training platforms such as National Virtual Simulation Training Center and Provincial Demonstration Platform for Integration of Production and Education, a collaborative education mechanism for moral cultivation and skills training has been determined. The school is exploring an innovative

education model for professionals in the field of intelligent manufacturing of prefabricated building components. Through reasonable curriculum design and comprehensive practical teaching facilities, students can better access to the required professional knowledge and skills. Through the teaching implementation, process monitoring, quality evaluation and continuous improvement, a cultivation model with strong practicality, systematicity and advanced nature has been formed, which has importan significant reference value for the development of related majors in domestic higher vocational colleges.

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Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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