Research on the Digital-Intelligent Transformation of Curriculum-Based Ideological and Pollical Education in Prefabricated Construction under the Construction Industrialization 4.0 Era

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Abstract. The concept of 'Industrialisation 4.0' in the field of construction places significant emphasis on intelligence and digitalisation, thereby driving a transformation of the entire prefabricated construction chain, from production to construction.In this context, the deep integration of ideological and political education with digital and intelligent technologies has emerged as a pivotal pathway for cultivating applied-type talent.The present paper adopts a 'student-oriented' approach, benchmarking against the standards of 'positions, courses, competitions, certificates, and innovation'. The construction of a 'five-dimensional, dual-cultivation' teaching model integrates the 'new standards for prefabricated buildings' and 'four new technologies' into the entire teaching process.Through the implementation of strategies such as the construction of a case library, virtual simulation teaching, and the establishment of an intelligent evaluation system, this paper explores an effective path for the ideological and political digital and intelligent transformation of prefabricated building courses. This provides both theoretical support and practical reference for professional education in construction engineering in the new era.

Keywords: Construction Industrialization 4.0 Era, Curriculum-Based Ideological and Pollical Education, Digital-Intelligent Pedagogy, Prefabricated Construction

1 Introduction

The global construction industry is undergoing significant transformative shifts driven by Industry 4.0, with digital technologies projected to encompass 62% of the construction chain by 2025 (IFCR, 2023). China aims to achieve a 40% share of prefabricated buildings in its industry by 2030, however, 72.6% of construction universities are facing challenges in providing balanced technical-value education (Ministry of Education, 2023). The challenges faced by the field include dissonance between technology and ethics, the utilisation of pedagogies that are no longer aligned with contemporary best

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practice, and misaligned assessments. Despite the fact that Building Information Modeling (BIM) is employed in 80% of Chinese industry, only 34% of Chinese institutions offer instruction in the subject (Architectural Society of China, 2022). Moreover, traditional pedagogical methods yield ideological internalisation rates of less than 41%. Recent international studies have proposed various solutions. Smith & Tanaka (2023) demonstrate that digital twins can enhance ethical-technical skills in U.S. – Japan education[1]. Wong & Schmidt (2022) establish a link between BIM and sustainability in German-Chinese curricula[2]. Lee et al. (2023) utilise VR to enhance green ethics in South Korea, Spain, and the U.S., while Nguyen et al. (2022) advocate for strengthened industry-academia collaborations to facilitate Industry 4.0 in Vietnam and India[3][4]. Al-Mohammed & Rossi (2023) emphasise the importance of localized ethics in Middle Eastern-European programs[5].

In response to the industrialisation of Construction 4.0, developed countries have restructured their engineering education systems through the two-way coupling of technological empowerment and value penetration (OECD, 2023 Vocational Education Report). The implementation paths of curriculum ideology in Germany, Japan, Singapore, and China are compared in Table 1, based on the team's research.

Table 1. Curriculum implementation path for ideological and political education.

Country	Technology carrier	Mode of ideological and political infiltration	Corporate participation (%)	Student satisfaction (%)
Germany	Industry 4.0 training platform	Dual system invisible curriculum	93.4	88.7
Japan	BIM+VR collaborative system	Situational simulation of craftsmanship spirit	76.2	79.3
Singapore	Digital twin city model	SDGs project-based learning	85.1	91.4
China	PPT multimedia	Theoretical preaching	32.8	56.9

A comparative analysis reveals common patterns in curriculum reform, including the concrete binding of technical carriers to ideological and political goals, the reverse shaping of teaching systems by industry standards, and the same origin of data from teaching processes and production processes. This provides an important reference for China to break through the dilemma of 'lecturing with PPT'. The present study explores the integration mechanism of technical rationality and value rationality in prefabricated building education by constructing a framework for digital and intelligent transformation, providing a solution to the dilemma of cultivating talent in the new engineering field.

2 General Design of Ideological and Political Education in the Curriculum

Ideological and political education in the curriculum, i.e. education through the curriculum, is a key method of cultivating students' correct world outlook, outlook on life and values. The teaching team for Prefabricated Construction is acutely aware that classroom teaching is not only about learning knowledge, but more importantly, it is about enhancing students' minds, improving their ability to correctly understand, analyse and solve problems, and strengthening the education of professional qualities in construction engineering. The teaching team has integrated ideological and political elements into the entire process of green construction, guiding students to establish ideals and beliefs dedicated to the cause of the motherland's construction in the context of 'strengthening the country through skills', and cultivating 'green building pioneers' with a green cultural heritage, superb construction skills, and an outstanding artisan spirit. The ideological and political education goals of the course are achieved through the ideological and political construction of the course, guided by the main purpose of cultivating students' spirit of "great craftsmen" as engineers. The two core themes are "labor education" and "green construction", and by constructing four major ideological and political teaching situations, students' core values are subtly shaped. The course is underpinned by the fundamental principle of cultivating virtue and shaping character, guided by the values of 'honourable labour, valuable skills and great creativity'. It employs an approach that enhances students' prefabricated construction production and construction skills as a vehicle, with the shaping of the spirit of craftsmanship as the core guiding principle. This is promoted through a layered process of 'maintaining craftsmanship - honing skills - forging the soul - putting it into practice', with the overarching aim of achieving the integration of virtue and skills. The course is delivered via an online medium or through a blended online and offline teaching model, with the fundamental objective of cultivating students' vocational skills and professionalism. The course integrates the certificate, incorporating the certificate of skill level for fabrication and installation of prefabricated construction components into the curriculum, and reconstructing the teaching content based on the work process. Case studies of ideological and political education are explored based on the actual work process of prefabricated buildings, so as to achieve the complementary advantages of ideological and political elements and teaching content.

3 Construction of a Digital and Intelligent Transformation Framework

3.1 Theoretical Model Design

The present study is based on the theory of complex adaptive systems (CAS), and its objective is to construct a three-dimensional transformation model of 'value-technology-ecology'. The design logic and operating mechanism of this model reflect the characteristics of multi-dimensional collaboration. In the design of the value layer, three major value target systems are established, including the internalisation of technological ethics, the construction of cultural confidence, and the cultivation of sustainable development capabilities. This is achieved by integrating the core requirements of the 'Guidelines for the Construction of New Engineering' and the 'Guidelines for the Construction of Ideological and Political Courses in Colleges and Universities'. The technology layer builds an intelligent teaching platform based on BIM+5G+blockchain. The ecosystem layer proposes a collaborative education mechanism of 'government-university-enterprise-industry' to form a closed loop through the linkage of the four parties of government, industry, academia and research.

3.2 Development of Core Modules

In the construction of the digital ideological and political resources database, the research team employs knowledge graph technology to construct a multi-modal resource system encompassing four primary categories: ethical conflict cases, historical construction archives, safety accident simulations, and sustainable design templates. A virtual teaching and research collaborative platform has been developed, which profoundly integrates three types of resources, including a cultural resource database, an inter-school collaboration network and a mechanism for integrating industry and education. The establishment of a special course group on 'prefabricated construction' has been achieved through the establishment of a partnership with major universities. The use of a digital twin platform by teachers allows for the joint planning of lessons across time and space, with the production of teaching cases that integrate diverse cultural backgrounds.

4 Teaching Practice of Ideological and Political Education in the Curriculum

4.1 Explore the Ideological and Political Elements of the Curriculum

The integration of the characteristics of the school and the major is achieved by the team of teachers through their exploration of the elements of ideological and political education, and the establishment of a resource base for these elements within the curriculum. The teaching task is employed in a precise manner to facilitate the integration of ideological and political education, thereby achieving a deep integration of these elements with the content of the course. The course is taught using a blended online and offline teaching model, drawing on teaching resources such as classroom teaching that fully incorporates the ideology and politics of the curriculum, virtual simulation training projects, and national first-class courses. The teaching process is predicated on three levels of ideological and political elements of patriotism, professionalism, and cultural heritage, with other ideological and political elements playing a supplementary role. Ideological and political education is integrated into the process of teaching implementation.

4.2 Optimise the Design of the Curriculum Ideological and Political System

Four major ideological and political teaching contexts have been constructed: “outstanding figures, major projects, typical accidents, and scientific and technological development”. Through methods such as invisible integration and explicit guidance, ideological and political elements are infiltrated into various teaching tasks. Students are encouraged to participate in internships and training, volunteer services, and other off-campus activities, with the objective of promoting learning, wisdom, and morality. These activities are designed to achieve the ideological and political teaching effect of ‘maintaining craftsmanship’, ‘sharpening craftsmanship’, ‘forging the soul of craftsmanship’, and ‘putting craftsmanship into practice’.

4.3 Innovative Curriculum and Teaching Model

A ‘five-dimensional, dual-education’ teaching model has been developed. In the teaching process, various resource platforms are employed to facilitate a realistic teaching environment. These include the ideological and political case resource library, the ideological and political VR experience centre, and the digital ideological and political simulation platform. The overarching objective of this approach is to create a teaching situation where the roles of teacher and student are reversed, projects are considered entities, and workshops are transformed into classrooms. This approach enables students to engage with their job responsibilities in the classroom and achieve value-led learning.

4.4 Innovative Curriculum and Teaching Methods

4.4.1 Flipped Classroom. Students are taken to a prefabricated construction industry demonstration base and production workshop. The invitation of renowned enterprise teachers and frontline production workers to teach in these settings enables students to intuitively experience the ‘new technologies, new processes, and new standards’ in the field of prefabrication. The objective of this component is to stimulate students' spirit of scientific and technological innovation and sense of responsibility. Simultaneously, they will experience the hardships and difficulties of frontline workers, thereby fostering an understanding that ‘labour is glorious and skills are valuable’.

4.4.2 Case Study. Typical production cases are employed throughout the teaching process, serving as a medium to facilitate students' engagement with the 'energy conservation and environmental protection' principles inherent in prefabricated construction, to appreciate the ‘Chinese speed and Chinese spirit’, to stimulate feelings of patriotism and cultural confidence, and to establish an awareness of green construction.

4.4.3 Role-Playing. Virtual simulation software is utilised to immerse students in a real production and construction environment, where they can simulate various roles and experience different job responsibilities, cultivating a good engineering work ethic.

5 Effectiveness of the Curriculum-Based Ideological and Pollical Education Teaching Reform

The data demonstrate a marked increase in student attendance, with levels exceeding 95% in each class. Concurrently, there has been a significant enhancement in course satisfaction, with students expressing a heightened level of interest in the course. Furthermore, there has been a substantial improvement in their knowledge and skill levels, as evidenced by an increase in the award rate in skill competitions from 0% to 100%. This is indicative of a joint participation between students and companies in the BIM Innovation Competition, with a minimum of 10 awards being secured. Concurrently, employer satisfaction has reached 96%, underscoring the efficacy of the programme. Furthermore, there has been a marked enhancement in students' environmental awareness, as evidenced by an increase of 30% in the compliance rate of green indicators in design schemes.

6 Conclusion

This study integrates ideological-political education with digital-intelligent pedagogy in prefabricated construction courses under Construction Industrialization 4.0. By establishing a “five-dimensional, dual-cultivation” model and a “value-technology-ecology” framework, advanced technologies synergise with value shaping to cultivate ethically grounded professionals. Key innovations, including immersive teaching methods, a multi-modal digital resource database, and a collaborative “government-university-enterprise-industry” ecosystem, have been identified as key drivers of enhanced student engagement, skill competition awards, employer satisfaction, and green compliance. This framework is poised to serve as a replicable solution for China’s engineering education, addressing the prevailing technology-ethics gap. Future research directions could include extending this framework to other disciplines and undertaking a comprehensive assessment of long-term societal impacts.

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