

Reconstruction and Practice of Digital Construction Collaborative Innovation Teaching System under the Background of Construction Industry Transformation and Upgrading

Zhao Xia^a, Jing Xiaoling^b, Luan Chengjie^c, Han Luyue^{d,*}, Ren Zhaojun^e, Li Na^f

School of Civil Engineering, Binzhou Polytechnic, Binzhou, China

^ayxzhaoxia@sian.com, ^bsdsjxl@163.com, ^cluanchengjie123@163.com, ^d*316012636@qq.com, ^e13769055@qq.com, ^f411245815@qq.com

*Corresponding author

Abstract: As a result of the transformation and upgrading of the construction industry, talent cultivation must keep pace with The Times. Compared with other majors, the transformation and upgrading of civil engineering requires more support of "digital construction". The traditional occupational positions in the construction industry have undergone tremendous changes, requiring employees to transform and upgrade accordingly. As a base for training talents in the construction industry in vocational colleges, fundamental changes must be made to adapt to the impact of the transformation and upgrading of the construction industry. The vocational colleges need to clarify the new occupational positions required for the transformation and upgrading of the construction industry, create a "BIM + engineering entity" digital construction industry platform, set up a team of high-level full-time teachers led by doctors, compile national planning teaching materials for digital construction that integrate "ideological and political", and innovate cross-border coupling collaborative linkage teaching method, develop the shared information-based digital construction resources in the new construction industry, reconstruct the digital intelligent three-dimensional teaching ecological environment, upgrade the digital tracking whole process evaluation system and other "eight-dimensional" digital reforms, create digital construction collaborative innovation teaching System, cultivate qualified new construction talents and achieve zero-distance connection with the transformation and upgrading of the construction industry to implement the digital transformation and practice of the teaching system of civil engineering majors in the transformation and upgrading of the construction industry, and realize the systematic and timely training of construction talents.

Keywords: Transformation and upgrading; digital construction; collaborative innovation; teaching system.

1. Introduction

The transformation and upgrading of the construction industry is a revolution, and the core is digital technology. The digitalization index of McKinsey Global Institute shows that the construction industry is one of the industries with the worst digitalization level, ranking second from the bottom. Therefore, the state has successively issued programmatic documents such as the "Thirteenth Five-Year Plan for the Development of the Construction Industry" and "Several Opinions on Accelerating the Development of New Construction Industrialization" to accelerate the transformation and upgrading of the construction industry. These documents put forward new tasks for the revolutionaries of digital technology-talents, and provide comprehensive challenges to schools, the suppliers of technical talents, implement national strategies^[1-5] such as the National Vocational Education Reform Implementation Plan, the Action Plan for Quality Improvement and Excellence in Vocational Education (2020-2023), and create a "BIM (Building Information Modeling) + Engineering Entity" digital construction industry platform, start from the "three teachings" reform and reconstruct the traditional teaching system of civil engineering majors, form a collaborative innovation teaching system for digital construction, and provide a systematic teaching reform plan for the training of "digital craftsmen" skilled personnel in civil engineering majors.

2. The need for reform

2.1 The transformation and upgrading of the construction industry puts forward new tasks for the teaching system of civil engineering majors

General Secretary Xi Jinping attaches great importance to the construction of ecological civilization and green development, and has repeatedly emphasized that the construction of ecological civilization is the fundamental plan related to the sustainable development of the Chinese nation. It is necessary to implement the general secretary's ecological civilization thought and the spirit of the 19th National Congress of the Communist Party of China, promote the green development and high-quality development of urban and rural construction, drive the comprehensive transformation and upgrading of the construction industry with new construction industrialization, and create an internationally competitive "Made in China" brand. At present and in the future, these documents will guide the development of new construction industrialization, improve the construction level and construction quality, and drive the overall transformation and upgrading of the construction industry. According to the requirements of the "Several Opinions", the development of new building industrialization is a complex systematic project. It is necessary to focus on integrated design, standardized design, green building materials, steel structure buildings, prefabricated concrete buildings, information technology integration, promotion of BIM technology, development of intelligent Construction, scientific and technological support, as well as professional personnel training, etc.

Supported by new production factors such as knowledge, technology, information, and data, Shandong Province takes the supply-side structural reform as the main line, new technologies, new industries, new formats, and new models as its' core, and the promotion of industrial intelligence, smart industrialization, cross-border integration and high-end branding as its' goal. It is proposed to build a comprehensive pilot area for the conversion of new and old kinetic energy in Shandong ^[6].

Both the country and Shandong Province are carrying out the transformation and upgrading of the construction industry. The transformation and upgrading of the construction industry will inevitably require the corresponding transformation and upgrading of teaching systems such as teachers, students, and textbooks for civil engineering majors, so that they can participate in the integrated development of information technology, and Vigorously promote and apply BIM technology, big data technology and Internet of Things technology, and develop new tasks such as intelligent construction.

2.2 Industrial digital transformation poses new challenges to the construction of digital construction teaching system for civil engineering majors

The construction industry should realize industrialization, informatization and greenization, and the connotation behind the "three modernizations" is "to make the construction industry achieve modern industrialization" ^{[1][7]}. By building a digital construction industry platform, using digital design, digital construction, digital operation and maintenance, and the application of AI and BIM technologies to speed up the progress of the project, reduce the cost of the project, and improve the quality and safety of the project. The construction industry uses advanced productivity and production technology represented by digital technology to promote the development and transformation of the construction industry. The industry have entered a new era of digital transformation with the continuous emergence of "digital economy", "digital enterprise", "smart building", "smart city" and so on

Digital technology poses new challenges to schools while it facilitates the transformation and upgrading of the construction industry. As the cradle of cultivating digital talents, the school is facing a comprehensive reform, upgrade and reconstruction of the teaching system, including the basic structure of knowledge in the teaching process, teaching content, teaching methods, teaching process facilities and teaching results evaluation, etc. The transformation and upgrading involve the main elements such as teachers, students, teaching materials, etc. and make the training of talents can keep up with the development of the digital trend era.

2.3 "BIM information technology +" improves the upgrading and transformation requirements of traditional majors for civil engineering majors

"BIM information technology +" accelerates the construction of smart campus, promotes the deep integration of information technology and intelligent technology into the whole process of education, teaching and management services, improves teaching, optimizes management, and enhances

performance. The technology upgrades traditional majors and develops emerging majors spawned by the digital economy in a timely manner. The technology adapts to the needs of "Internet + vocational education", promotes the co-construction and sharing of digital resources, excellent teachers as well as educational data, and upgrade the education service supply model. It also improves the information literacy of teachers and students, builds smart classrooms and virtual factories, and widely applies online and offline mixed teaching to promote autonomous, ubiquitous, and personalized learning.

2.4 "Double high" construction of "three teachings" reform and construction of technological innovation platform to promote the deepening reform of the teaching system

The reform of teachers, teaching materials and teaching methods has been comprehensively deepened [4] [5] [8]. With the accumulation of technical skills as the link, the platform will build a talent training and technology innovation platform integrating talent training, team building and technical services, resource sharing, flexible mechanism and efficient output, and an industry-education integration platform reflecting the characteristics of the school, serving regional development and industrial transformation and upgrading. Schools and enterprises jointly develop scientific and standardized talent training programs and curriculum standards that can be used for reference internationally, incorporate advanced industrial elements such as new technologies, new processes, and new norms into teaching standards and teaching content, and build open and shared professional group curriculum teaching resources and practical teaching base. Schools and enterprises establish a high-level, structured teaching innovation team for teachers, explore a modular teaching model of division of labor and collaboration among teachers to deepen the reform of teaching materials and teaching methods as well as promote classroom revolution.

2.5 The interactive development of innovation 2.0 and the new generation of information technology accelerates the construction of a collaborative innovation teaching system

As an innovation oriented to the knowledge society [9], Innovation 2.0 is the construction of an innovative ecology of the "government, application, production, education and research" system, which promotes the cooperation and coordination of government, application, production, academia and research. The factors of the knowledge society environment and demand have contributed to the vigorous development of innovation 2.0 practices. Collaborative innovation is a new development of innovation 2.0 from open innovation to mass innovation. It is a more complex innovation organization method, emphasizing the collaborative interaction, in-depth cooperation, and resource optimization and integration of multiple subjects. As a member of collaborative innovation, schools should give full play to their advantages in talent and technology, and use information technology to accelerate the construction of a collaborative innovation teaching system.

3. Digital Construction Collaborative Innovation Teaching System Reconstruction

The reconstruction of the digital construction collaborative innovation teaching system mainly carried out the "eight-dimensional" digital reform, as shown in Figure 1, that is, traditional jobs reconstruct digital positions, traditional technical talents reconstruct digital craftsmen talents, traditional teaching resources reconstruct digital information sharing resources, Traditional textbooks reconstruct digital teaching materials, traditional teaching methods reconstruct digital ecological teaching methods, traditional teachers reconstruct digital "double-teacher" teachers, traditional classrooms reconstruct digital ecological classrooms, traditional evaluations reconstruct digital tracking of the whole process evaluation to form a digital construction collaboration The innovative teaching system is shown in Figure 2.

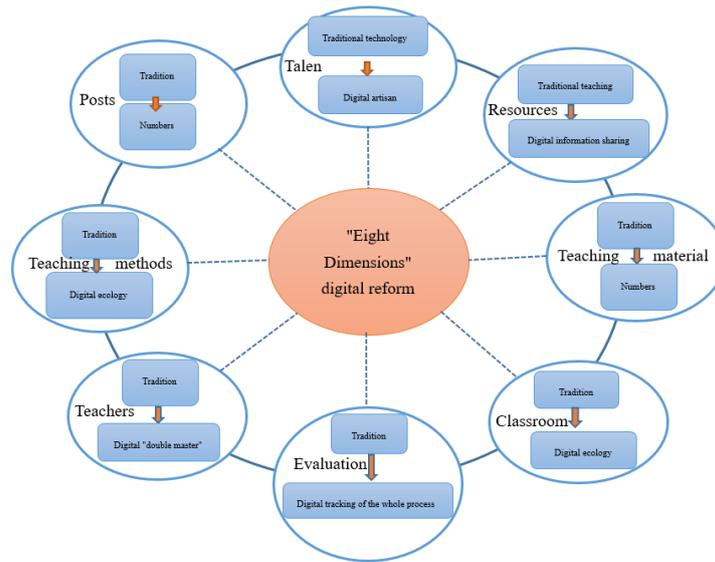


Figure 1: "Eight Dimensions" digital reform diagram.

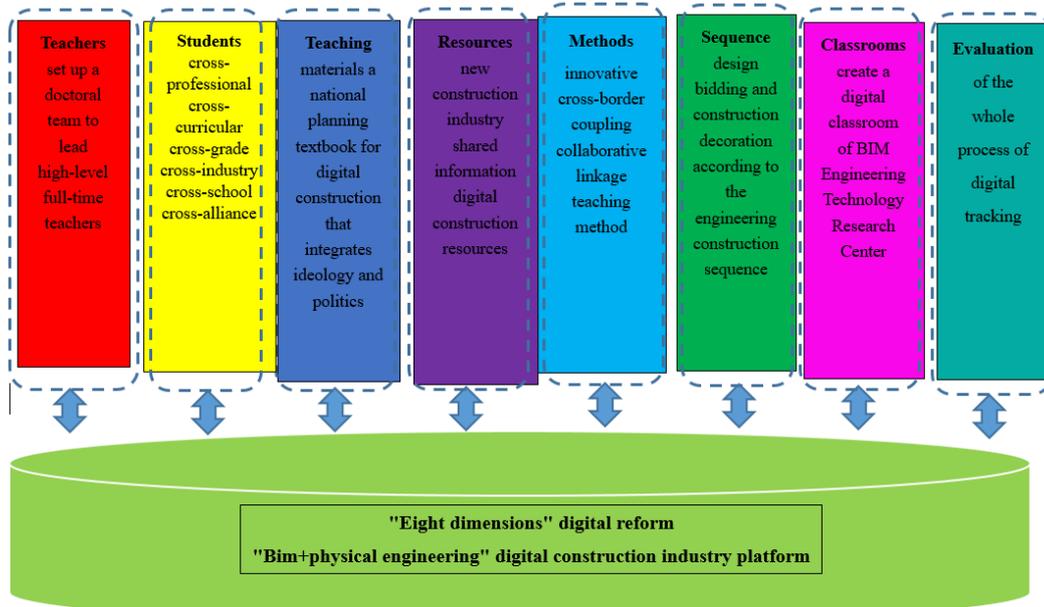


Figure 2: Digital construction collaborative innovation teaching system.

3.1 Transformation and upgrading of occupational positions—Clarifying the new occupational positions required for the transformation and upgrading of the construction industry

It is important to deepen the supply-side structural reform of vocational education, establish a data platform for industrial talent, release industrial talent demand reports, and promote the precise connection between vocational education and industrial talent demand [5]. The transformation of old driving forces in the transformation and upgrading of the construction industry will give rise to new job groups, and the transformation and upgrading of traditional job groups to digital intelligent construction job groups. Personnel training upgrade from ordinary technical personnel to "digital craftsman" skills training. "Several Opinions" emphasize that the improvement of construction industrialization, construction level and quality will drive the overall transformation and upgrading of the construction industry. Compared with the traditional construction industry, the posts of building information modeling (BIM technology), intelligent design, intelligent construction and assembly construction are newly added, and the traditional posts of budget, cost, construction, interior design and decoration are upgraded.

3.2 Transformation and upgrading of teaching platform—Creating "bim+engineering entity" digital construction industry platform

The development of new building industrialization clearly accelerates the development of information technology integration, vigorously promotes BIM technology, and develops intelligent construction. The construction industry must realize industrialization, informatization and greenization, and the connotation behind the "three modernizations" is to "elevate the construction industry to the level of modern industrialization". In order to meet the needs of new jobs in the construction industry, BIM technology is used to create a digital construction industry platform, including Binzhou Vocational College No. 2 teaching building, new student apartments, high-rise residences in Huaqingyuan, Yellow River Delta Talent Training Center, Min'an Quehuayuan 6# Prefabricated residential high-rise buildings. Use digital design, digital construction, digital operation and maintenance, and the application of AI and BIM technologies to accelerate the process of construction industrialization. Built 1 Binzhou Engineering Research Center for Digital Construction Collaborative Innovation, 1 Binzhou BIM Engineering Technology Research Center, and the Ministry of Education's "Higher Vocational Education Innovation and Development Action Plan (2015-2018)" project recognized the construction professional production training base 1. The Binzhou Construction Industry Modern Vocational Education Alliance was established to further deepen school-enterprise cooperation.

3.3 Transformation and upgrading of the teaching team—The formation of a doctoral team leading a high-level "double-qualified" full-time teaching team

Team building is proposed in the reform of "Double High" and "Three Teachings", forming a high-level and structured teaching innovation team of teachers, breaking the traditional pattern of teachers fighting for each other, setting up a high-level teaching team led by doctors and professors, with the BIM Research Center, the Doctoral Research Center and Shandong Province Famous Teachers Studio as the platform, to fight collectively across disciplines, and to develop innovative teams that leverage their respective strengths for coordinated development. The reform will also help form a pyramid-style teaching team of professors, associate professors, lecturers, and teaching assistants, build a "double-qualified" teacher training system, focus on 1+X certificates such as BIM that are urgently needed for the transformation and upgrading of the construction industry, and apply for 3 credit system bank experts in Shandong Province. A credit-based guidance expert team is formed, and "double-qualified" teachers account for more than 80% of the professional teachers. Schools and enterprises jointly build a "double-qualified" teacher training base and a teacher enterprise practice base, and build three college-level teacher teaching innovation teams, cultivate 1 famous teaching teacher in Shandong Province, 1 outstanding sharing young expert in Shandong Province, 1 outstanding teaching team in Shandong Province, 1 overseas exchange student, and 5 participants in international BIM academic exchanges.

3.4 Using textbooks to transform and upgrade—To compile national planning textbooks for digital construction that integrate "ideological and political"

According to the new pattern of "three comprehensive education"^[10], vocational schools strengthen the party committee's overall leadership of the school's ideological and political work, implement all-round education for all staff and the whole process, guide vocational schools to comprehensively coordinate education resources and strengths in all fields, links, and aspects, educate and guide young students to enhance their sense of love for the Party and patriotism, listen to the Party, and follow the Party. Guide teachers of professional courses to strengthen the ideological and political construction of courses, and fully integrate ideological and political education into talent training programs and professional courses. Schools have completed 10 digital national plan "Twelfth Five-Year" and "Thirteenth Five-Year" textbooks, and are applying for the compilation of 5 books to connect with mainstream production technologies, Absorb new knowledge, new technology, new process and new method developed by the industry, and cooperate with schools and enterprises to develop professional course teaching materials. The schools innovate the form of teaching materials, and implement scientific and rigorous, explain the profound things in a simple way, with pictures and texts, and various forms of loose-leaf, workbook, and media-integrated teaching materials in accordance with the characteristics of civil engineering students,.

3.5 Transformation and upgrading of teaching methods—Innovative teaching methods of cross-border coupling and collaborative linkage

New teaching method breaks the traditional teaching method of teachers and students taking the classroom as the main body, and adopts a cross-border coupling teaching mode through inter-professional (architectural engineering technology, engineering cost, architectural interior design, art design), cross-curricular (architectural engineering technology professional course group, engineering cost professional course group, interior design professional course group), cross-grade (1st, 2nd, 3rd Grade students participate together), cross-industry (civil construction industry, cost auditing industry, decoration design industry), cross-school (school, enterprise integration of production, education and research), cross-alliance (Binzhou Vocational College Urban Construction Joint Council, Binzhou Construction Industry Modern Vocational Education Alliance) to collaborate in teaching. The new methods give full play to the strengths of professional teachers and corporate teachers, lead some students to innovate and start businesses, and promote colleges and universities to realize the combination of work and study talent training as well as the reform of the practical teaching system to create a cross-professional combined innovation team composed of teachers and students, reserve talents for participating in various skill competitions and innovation and entrepreneurship competitions, and cultivate qualified talents for the transformation and upgrading of the construction industry.

3.6 Transformation and upgrading of teaching resources—Development of shared information digital construction resources for new construction industry

The new transformation promotes the collaborative innovation of government, application, production, academia and research to develop new construction industry technical resources, share technical resources, break through the barriers between innovation entities, and fully release the vitality of innovation elements such as "talents, capital, information, technology", realizing in-depth cooperation based on the interactive development of innovation 2.0 and the new generation of information technology, the construction of an innovative ecology of the "government-utilization-industry-university-research" system. The transformation realizes the collaborative interaction, in-depth cooperation, and resource optimization and integration of multiple subjects, and develops interactive three-dimensional teaching resources to serve schools, enterprises, governments, and construction industry modern vocational education alliances.

3.7 Classroom transformation and upgrading—Reconstruction of digital intelligent three-dimensional ecological teaching environment

Traditional teaching is to rush a large number of students to a fixed place for centralized face-to-face teaching, and teachers and students have adapted to this teaching environment, but in the post-epidemic era, a virus has spawned a series of teaching reforms, bringing classrooms to the "cloud". The reform organically combined classroom teaching and learning, virtual teaching and learning, and cloud-based teaching and learning to reconstruct the digital ecology classroom with the help of Binzhou BIM Engineering Technology Research Center.

3.8 Transformation and upgrading of teaching evaluation—Innovating the whole process evaluation system of digital tracking

The traditional teaching evaluation has always been to use the method of examination to evaluate a student's academic performance, and to use the cross-border coupling and collaborative linkage teaching method to teach and learn, to evaluate a student's comprehensive quality, and to carry out a stage digital tracking continuous whole process evaluation system. The new evaluation system innovates the passive scoring of students, and actively strives for process evaluation scores through weekly and monthly reports on course learning and application of innovative technologies and the next learning plan, which changes from passive to active, stimulates students' fighting spirit for learning, and corrects their ideological attitudes to take their studies seriously.

4. The practical effect of digital construction collaborative innovation teaching system

Through the long-term and unremitting joint efforts of the project team and various fields of the construction industry, the results construction have achieved outstandingly, which are mainly reflected

in the following aspects.

4.1 The joint training of teachers has achieved remarkable results

After several years of curriculum reform and construction, the school has trained a large number of "double-qualified" teachers, each of whom has obtained an industry practice qualification certificate, and the strong teaching team has improved their teaching ability. The school has trained 1 famous teaching teacher in Shandong Province, 1 young and middle-aged expert with outstanding contributions in Shandong Province, 1 winner of Shandong Province "May 1st" labor medal, 1 Binzhou city youth professional and technical leader, 1 Binzhou City "Five 1st" labor medal winner, 1 "Labor Medal Winner", 1 "Top Ten" professional and technical leader in Binzhou City, 3 outstanding teachers in Binzhou City, and many famous teachers at the college level. Among the 27 teachers, 21 of them are recognized by the college as "double-qualified" teachers, reaching 78%.

4.2 Remarkable achievements in the connotation construction of civil engineering

Binzhou Vocational College has developed 15 provincial-level quality courses and provincial-level quality resource sharing courses. The college belongs to the Shandong Provincial Department of Education and the Provincial Higher Vocational School Brand Professional Group, has National Key Higher Vocational College Construction Plan Major supported by the Ministry of Education and the Ministry of Finance. It's also the national productive training base of the Ministry of Education and a national collaborative innovation center. The college has 2 second prizes for national teaching achievements, 2 first prizes for provincial teaching achievements, 8 Shandong Vocational College Skills Competitions, and 4 Shandong Vocational College Teaching Ability Competitions. The college also has 1 provincial teaching team, 1 provincial famous teaching teacher, 1 provincial higher vocational education famous teacher studio, and 2 professional teaching guidance programs in Shandong Province. The college has published 9 papers, including "Research on the Development and Application of Three-dimensional Teaching Resources for Core Courses of Civil Engineering Majors" and "Research on the Development of Comprehensive Digital Teaching Platform for Civil Engineering Majors in Higher Vocational Colleges", and compiled 10 digital textbooks, of which 4 are national "Twelfth Five-Year" planning textbooks, 3 national "Thirteenth Five-Year" planning textbooks, 8 invention patents and 10 utility model patents.

4.3 Significant improvement in student recruitment, employment and competition

The number of students in the School of Architecture and Engineering of Binzhou Vocational College has increased from 300 to 440 now. Civil construction students have maintained an upward trend in enrollment for three consecutive years despite the current decline in the national student population, and the student employment rate has reached 98%. For many years, a new teaching system has been implemented for teaching, the training of talents has been seamlessly connected with the construction industry. And Students have won 37 skill competitions.

5. Future construction prospects

As an important part of the construction industry, vocational colleges have the ability and obligation to make due contributions to the transformation and upgrading of my country's construction industry. This research project will continue to increase construction investment and expand implementation efforts, focusing on training talents and enterprise post docking tracking research, adjust the corresponding elements of the teaching system in a timely manner through the feedback information of enterprises on the use of talents, so that the professional and technical talents trained in the follow-up are more suitable for the continuous transformation and upgrading of the construction industry.

Artificial intelligence technology has rapidly penetrated the education industry, forming ecological intelligent education, using intelligent technology to accelerate the reform of talent training models and teaching methods, and build a new education system that includes intelligent learning and interactive learning. The college should carry out the construction of intelligent campus and promote the application of artificial intelligence in the whole process of teaching, management, resource construction and so on, develop a three-dimensional comprehensive teaching field and an online learning and education platform based on big data intelligence, develop intelligent educational assistants, establish intelligent, fast and comprehensive educational analysis systems and establish a learner-centered educational environment to

provide accurate education services and realize the customization of daily education and lifelong education.

The reform of the talent training system is a systematic project, which requires the coordination of multiple departments.

Acknowledgements

Shandong Province Education Reform Project "Development of Comprehensive Digital Teaching Platform for Civil Engineering Majors in Higher Vocational Colleges under the Technical Conditions of 'Internet + BIM'" .

References

- [1] Ministry of Housing and Urban-Rural Development of the People's Republic of China. *Construction Industry Development "13th Five-Year Plan"* [E]. 2017.04.26.
- [2] The State Council of the People's Republic of China. *The Guiding Opinions of The General Office of the State Council on Vigorously Developing Prefabricated Buildings (State Affairs development [2016] No. 71)* [E]. 2016.09.30.
- [3] Ministry of Housing and Urban-Rural Development, PRC. *Some Opinions of the Ministry of Housing and Urban-Rural Development and other departments on Accelerating the industrialization development of New Building Construction standard Regulation ([2020] No. 8)* [E]. 2020.08.28.
- [4] The State Council of the People's Republic of China. *National Vocational Education Reform Implementation Plan* [E]. 2019.01.24.
- [5] Ministry of Education of People's Republic of China. *Action Plan for Improving quality and Fostering Excellence of Vocational Education (2020-2023) (Qicheng [2020] No.7)* [E]. 2020.09.16.
- [6] State Council of People's Republic of China. *General Construction Plan of Shandong Comprehensive Pilot Zone for Transformation of Old and New Kinetic Energy (Guohan [2018] No.1)* [E]. 2018.01.10.
- [7] State Council of People's Republic of China. *Opinions of The General Office of the State Council on Promoting the Sustainable and Healthy Development of The Construction Industry (State Council Development [2017] No. 19)* [E]. 2017.02.24.
- [8] Ministry of Education of the People's Republic of China. *Opinions of Ministry of Education and Finance on the Implementation of High-level Vocational Schools and Specialty Construction Plan with Chinese Characteristics (Qicheng [2019] No. 5)* [E]. 2019.04.17.
- [9] China Industrial Research Institute. *2021-2025 China's new generation of information technology industry in-depth research and investment prospects forecast report [D]. May 2021* 2021.05.
- [10] Ministry of Education of the People's Republic of China. *Opinions on Strengthening and Improving Ideological and Political Work in Universities under The New Situation* [E]. January 2, 2019, 2019.01.02.