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Digital Transformation of Engineering Education—The Practices in Chinese Universities

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Abstract: With the development of a new round of scientific and technological revolution, digital technologies represented by artificial intelligence and big data have promoted the digital transformation of the manufacturing industry. The digital transformation of manufacturing industry not only puts forward new requirements for industrial development, but also poses new challenges to the training of engineering talents. China attaches great importance to the digital transformation of education, especially in the field of engineering education. Many universities in China, especially those with expertise in engineering, have carried out pilot and exploration of the digital transformation of engineering education. Based on the field investigation, public data investigation and interviews with engineering teachers in a number of Chinese universities, this paper uses the text analysis method to summarize the practice and reform of the digital transformation of engineering education in Chinese universities based on the practice of these universities, finds the coexistence problems, and puts forward some countermeasures and suggestions.

From the existing practice, each university mainly from the talent training goal, talent training mode, curriculum, practical training, teacher team construction, campus environment construction to carry out the exploration. At the same time, it can also be found that there are still some problems to be solved in the process of promoting the digitization of engineering education in Chinese universities. The integration between the digital curriculum and the original professional curriculum is not high; The digital skills of teachers are weak, and it is difficult to integrate professional knowledge and digital skills in teaching. The teaching of professional application scenarios of digital skills is insufficient, and students' learning of digital skills mainly stays in the theoretical learning stage.

Therefore, this paper puts forward countermeasures and suggestions from the following three aspects. Strengthen the construction of teaching materials that

integrate digital skills with professional knowledge, and provide relatively standardized and cutting-edge knowledge system for students' learning and teachers' teaching; Strengthen the training of interdisciplinary doctoral students, take digital skills as the necessary skills of engineering doctoral students, so that they have the corresponding knowledge and ability before becoming teachers; Provide enterprise-like environment for students to apply digital skills to solve problems in professional fields, and improve digital skills in real scenario training. In order to provide effective suggestions and references for the digital transformation of engineering education in China.
Key words: Engineering Education; Digital Transformation; Chinese practice

1 Introduction

Currently, the new round of technological revolution and industrial change is developing deeply, and digital technology represented by artificial intelligence, big data, etc. is becoming more and more an important force to change the way of human production and life. In recent years, countries around the world have introduced relevant strategies to promote digital transformation in various fields, especially in the manufacturing sector. The digital transformation of the manufacturing industry not only puts forward new requirements for industrial development, but also puts forward brand-new challenges for the training of engineering talents, and engineering education must adapt to the needs of the digital development of the industry to cultivate talents with both professional skills and digital skills.

China attaches great importance to the digital transformation of education. In 2023, the Ministry of Education of the People's Republic of China (MOE) implemented the "National Education Digitalization Strategy Action", and hosted the World Conference on Digital Education (WCDE) for two consecutive years in 2023 and 2024, which showed the world the latest progress of China's digital transformation of education and its future plans. In the field of engineering education, China will start the pilot construction of the National Academy of Engineer Excellence in 2022, aiming to accelerate the cultivation of a large number of engineers of excellence to support the high-quality development of China's manufacturing industry, and to strengthen the digital skills of engineering talents, which will become an important part of the cultivation of engineers in China in the present and the future. Many Chinese universities, especially those with a strong engineering focus, have launched pilots and explorations of digital transformation in engineering education.

We have conducted interviews or surveys of public information in Chinese universities, including Tsinghua University, Beihang University, Tianjin University, Shanghai Jiao Tong University, Zhejiang University, Tongji University, University of Science and Technology Beijing, Xidian University, China University of Petroleum (East China), and East China University of Science and Technology, and we have interviewed nearly 30 engineering faculty members, resulting in nearly 50,000 words of interview data.

Based on the aforementioned materials, this study primarily employs a text analysis approach for data analysis and research. First, the two authors independently read the texts and recorded frequently occurring words and concepts. Second, based on talent cultivation practices, theoretical research, and interview data, the two authors established the content framework for Sections 3 and 4 of this paper. They then jointly discussed how to integrate the frequently occurring words and concepts into each section, ultimately forming a coherent and complete content structure for this study.

Additionally, this paper adopts a case study approach, presenting the well-established practices of certain universities in a concise yet comprehensive case format to help readers better understand specific aspects of practical implementation.

Through the educational practices of these universities, this study aims to summarize the practices and reforms related to the digital transformation of engineering education in Chinese universities, identify common challenges, and propose several policy recommendations.

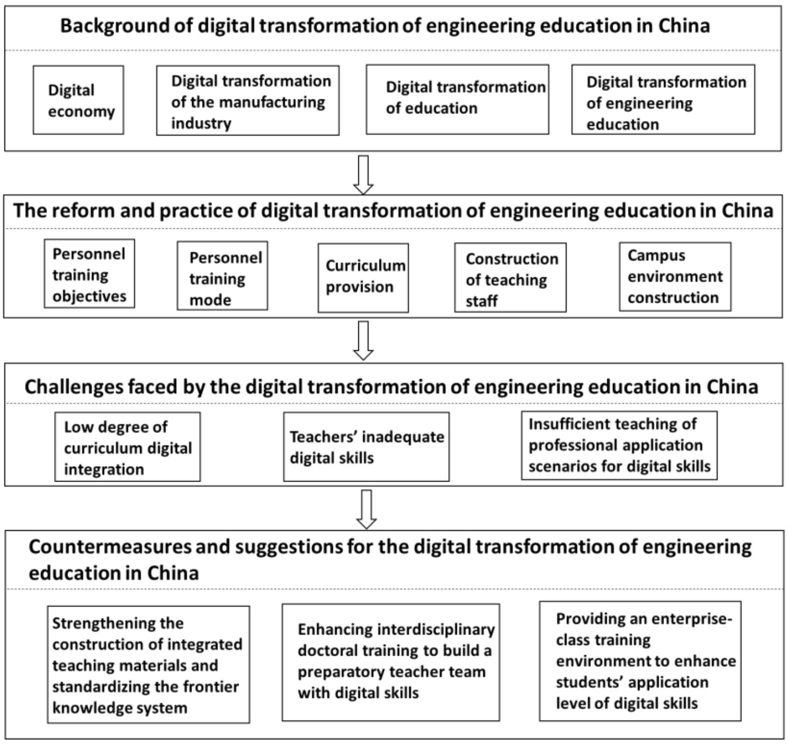

Figure 1 The framework of the paper

2 Background of digital transformation of engineering education in China

2.1 Digital economy

Since the 1940s, the invention of electronic computers and the rapid popularization of communication equipment and information networks have triggered drastic changes in science and technology and social economy, which is called the "digital revolution", also known as the third industrial revolution or the third scientific and technological revolution. Accordingly, the form of social and economic development has also undergone great changes. Following the agricultural economy and industrial economy, a new economy that is based on communication technology and uses networks, especially the Internet as carriers has emerged--the digital economy. It facilitates the production, distribution, exchange and consumption of resources through information network, which has attracted global attention.

In 1995, Canadian scholar Don Tapscott first proposed the concept of "digital economy"[1]. With the digital economy entering a more mature stage, scholars have a more comprehensive definition of the connotation of digital economy. The G20 Digital Economy Development issued by the G20 Hangzhou Summit held in China in 2016 gives the definition of digital economy as follows: "Digital economy refers to a wide range of economic activities in which digitization of information and knowledge is the key factor of production, modern information networks are the important carrier, and effective use of information and communication technologies is the important driving force for improving efficiency and optimizing economic structure[2]."

Looking back on the development of the digital economy, it can be divided into five periods. The 1940s to 1960s was the initial stage of the digital economy. In 1946, the United States Department of Defense developed the world's first general-purpose computer ENIAC, marking the official beginning of the digital economy era. From the mid-1970s to the mid-1990s, the development of the digital economy entered the initial growth period. With the emergence of large-scale integrated circuits, the size of computers has been further reduced, the performance has been further improved, and it has begun to spread to small and medium-sized enterprises and residents. From the mid-1990s to the beginning of the new century, with the development of personal computers and network technology, the network economy has developed rapidly.

After 2001, with the geometric growth of personal computer computing speed, storage scale and network speed, the continuous progress of mobile communication technology and the emergence of smart phones, PC Internet entered the mobile Internet era. In 2016, the technical foundation of the digital economy has come to a key era node, cloud computing technology has fully erupted, and the digital economy has entered a period of transformation and adjustment, developing in the direction of the Internet of Things, cloud computing big data, Internet of Things, and intelligence.

With the development of computers and the Internet, more and more new technologies, such as big data, cloud computing and artificial intelligence, have emerged, and these technologies are rapidly promoting the transformation of the global economy to digital, intelligent and efficient. The wave of digital economy has also swept China, changing the way people produce and live.

China attaches great importance to the development of digital economy. Since the 18th CPC National Congress, the CPC Central Committee has attached great importance to the development of the digital economy, elevating it to a national strategy[3]. The 19th CPC National Congress put forward a grand blueprint for building a "digital China" and a "smart society." Under the great attention of the Party and the state and a series of policy guidance, China's digital economy has developed rapidly, and its scale has long been ranked second in the world. The report of the Party's 20th National Congress further put forward the task of "accelerating the development of the digital economy, promoting the deep integration of the digital economy and the real economy, and creating an internationally competitive digital industrial cluster"[4]. This is of strategic significance for our country to build new national competitive advantages with the new advantages of digital economy and realize economic catch-up as soon as possible.

In terms of specific strategic planning, China has successively issued the Outline of the Digital Economy Development Strategy and the 14th Five-Year Plan for the Development of the Digital Economy, clarifying the direction and strategies for the development of the digital economy. Special attention has also been paid to the improvement of citizens' digital literacy, and the Action Program to Enhance Digital Literacy and Skills for All was issued in 2021, which made overall arrangements for how to vigorously enhance digital literacy and skills for all[5].

At present, China's digital economy is developing rapidly, showing the characteristics of rapid expansion of scale, steady improvement of industrialization level, and high-quality development of manufacturing industry.

In terms of the scale of the digital economy, the overall scale continues to expand, from 11 trillion yuan in 2012 to 45.5 trillion yuan in 2021. The average annual growth rate of the digital economy reached 17.6 percent, nearly nine percentage points higher than the average GDP growth rate during the same period. The proportion of digital economy in China's economy has also increased for many years in a row, from 21.6% in 2012 to 39.8% in 2021, an increase of 18.2 percentage points. Digital economy has become the most dynamic, most innovative and most extensive economic form.

On the level of digital industrialization, with the continuous breakthrough of digital technology innovation, China's digital industry continues to expand, and the level of digital industrialization has steadily improved. According to the calculation of the China Academy of Information and Communications Technology, the scale of China's digital industrialization has doubled from 4.2 trillion yuan in 2014 to 8.4 trillion yuan in 2021. The proportion of GDP rose from 6.8% to 7.3%, and the contribution of digital industrialization to China's economic growth is increasing.

In terms of the development of the manufacturing industry, with the rapid development of the digital economy, the manufacturing industry has also taken a solid step on the road of digital upgrading and transformation. The application of digital technology in the manufacturing industry has promoted the process of digitization and intelligence in the manufacturing industry, thus improving the competitiveness and production efficiency of the manufacturing industry. According to statistics, the digital transformation of China's manufacturing industry has accelerated, and the penetration rate of the digital economy in the manufacturing industry is higher than the average level of developing countries.

2.2 The digital transformation of the manufacturing industry

The wide application of digital technology has provided important driving force and support for the digital upgrading and transformation of the manufacturing industry, and promoted the sustainable development and improvement of China's manufacturing industry.

Since 2012, China has actively laid out and implemented relevant strategies to accelerate the transformation of the manufacturing industry. In 2013, the Ministry of Industry and Information Technology issued the "Special Action Plan for the Deep Integration of the Two Industrialization (2013-2018)", which for the first time took the promotion of the integrated development of the Internet and industry as a policy focus. In 2015, The State Council issued the "Internet Plus" action plan, once again highlighting the important role of the new generation of information technology in promoting the development of the manufacturing industry. In 2017, The State Council issued the Guiding Opinions on Deepening the "Internet + Advanced Manufacturing Industry" to develop the Industrial Internet, and the industrial Internet has become the path and methodology to support the digital transformation of the manufacturing industry.

On June 30, 2020, the Central Deep Reform Commission reviewed and adopted the Guiding Opinions on Deepening the Integrated Development of the New Generation of Information Technology and Manufacturing Industry, proposing to accelerate the integrated development of the new generation of information technology and manufacturing industry. The 2021 "14th Five-Year Plan" government report once again emphasized "accelerating digital development and creating new digital advantages." In October 2022, the Party's 20th National Congress report specifically emphasized "promoting the high-end, intelligent and green development of the manufacturing industry."

With the support of a series of policies and strategies, the digital transformation of China's manufacturing industry has made important progress in terms of institutional conditions, infrastructure, and Internet platform construction.

In terms of institutional conditions, the policy of digital transformation of the manufacturing industry has been continuously improved, providing an important guarantee for the development of digital transformation of the manufacturing industry. China has successively issued the "Action Outline for Promoting the Development of Big Data", "Guiding Opinions on Actively promoting the" Internet + "Action," Guiding Opinions on Deepening the Integrated Development of Manufacturing Industry and the Internet "and" Industrial Internet Development Action Plan (2018-2020) "and other corresponding plans, including product research and development, innovation transformation and application. Organizational growth and development, information infrastructure construction, information security and service platform construction, finance, taxation, talent and other aspects provide important support for the digital transformation of the manufacturing industry provides a strong institutional guarantee.

In terms of infrastructure, the construction of digital infrastructure has been strengthened. Breakthroughs have been made in the development and application of 5G, artificial intelligence, the Internet of Things, big data centers, and the industrial Internet, and a new type of network and converged infrastructure with advanced technology and powerful functions has gradually taken shape.

At present, the scale of 5G base station construction in China is close to 160,000, and 5G large-scale commercial use has been officially opened in 50 cities. The world's largest narrowband Internet of Things network has been built, and the number of cellular Internet of Things users has reached about 1 billion, accounting for more than half of the world. The overall supply scale of cloud data center resources has grown steadily, with a compound growth rate of more than 30% in recent years, and Alibaba Cloud has become the world's fourth largest cloud service provider. 32% of the computing power of the world's top 500 supercomputers comes from China, and edge data centers and edge computing are in the pilot stage, which is increasingly capable of providing infrastructure support for the digital transformation of the manufacturing industry.

In terms of Internet platform construction, the application of industrial Internet platform continues to expand. The industrial Internet is a typical representative of the integration of infrastructure to accelerate innovative development and application empowerment. At present, China is actively promoting the construction of an industrial Internet security monitoring and situational awareness platform linked by the national, provincial and enterprise levels. Basic telecommunications enterprises are accelerating the construction of low-delay, high-reliability, and large-bandwidth enterprise external networks, and some manufacturing enterprises are actively exploring the use of new network technologies for internal network transformation. Beijing, Shanghai, Guangzhou, Wuhan and Chongqing, the five national top nodes of identification analysis have been built and run, and 42 secondary nodes have been put into operation.

At present, China has more than 70 industrial Internet with strong influence in a certain region and industry, the average number of equipment connections across industries and cross-field industrial Internet platforms has 650,000, and the average registered users have exceeded 500,000.

2.3 The digital transformation of education

While enabling economic development, the digital economy not only promotes the transformation and upgrading of the manufacturing industry, but also sets off a wave of digital transformation in the field of education through changes in the industry's demand for human capital. The digital transformation of education came into being.

Education digital transformation is a digital process that uses digital technology and digital strategy to restructure organizational business and operational processes in the field of education, thereby promoting new organizational operational capabilities and governance capabilities, and improving operational performance in the field of education[6].

In the face of the digital era under the requirements of this industrial transformation, China has paid deep attention to and responded to the digital transformation of education. Education digital transformation plays an important role in China's digital strategy. In 2002, the Ministry of Education issued the "Tenth Five-Year Development Plan (Outline) for Education Informatization", marking that the development of digital education in China has entered a new stage. In 2012, the

Ministry of Education issued the 10-year Development Plan for Education Informatization (2011-2020), establishing the application-driven work policy and opening the application-driven stage of China's education digitalization. In 2018, the Ministry of Education issued the "Education Informatization 2.0 Action Plan", which established the basic principles of integration and innovation, marking the new journey of China's education digitization toward the intelligent era[7].

The "China Education Modernization 2035" issued by the CPC Central Committee and The State Council in 2019 proposed that by 2035, China will realize the overall modernization of education, and "accelerating the reform of education in the information age" will be included in the ten strategic tasks, emphasizing the use of modern information technology to accelerate the reform of personnel training mode, and realize the organic combination of large-scale education and personalized training[8].

In 2021, the Central Committee of the Communist Party of China and The State Council issued the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of 2035 Vision Goals, which requires focusing on key areas such as education, promoting the inclusive application of digital services, and planning the direction of technological innovation in education and teaching.

In 2022, the Ministry of Education will include the strategic action of education digitalization in the annual key work, marking that China's education has entered the stage of digital transformation. The "Key Points of the Ministry of Education in 2022" clearly states that it is necessary to implement strategic actions on education digitalization and accelerate the digital transformation and upgrading of education. The report of the 20th National Congress of the Communist Party of China also proposed to "promote the digitalization of education, and build a learning society and a learning country with lifelong learning for all."

In terms of government actions, in 2023, the Ministry of Education of China will deeply implement the "National Education Digitalization Strategic Action", take the national smart education platform as the first step and an important starting point, comprehensively optimize the supply of high-quality resources, support the implementation of major education reform tasks, continue to enhance international influence, and pave its own way to education digitalization development with Chinese characteristics.

In 2023 and 2024, the World Digital Education Conference was held for two consecutive years, showing the latest progress and future plans of China's digital education transformation to the world on topics such as teacher digital literacy and competence improvement, education digitization and learning society construction, artificial intelligence and digital ethics, and digital education evaluation, and building an international platform for digital education exchange and cooperation. Promote the common development of education around the world.

At the same time, the development of digital technology and related products has created technical support for the dissemination of educational information, enriched educational resources and technical means, and further promoted the digital transformation of education in terms of hardware facilities and educational methods. The application of the Internet and AI technology in the field of education has promoted the reform of the teaching model and spawned new teaching models such as MOOCs and flipped classrooms.

The integration of digital technology into education digitizes educational resources, promotes the dissemination of high-quality educational resources, and improves the equity of education. The integration of digitalization in the field of education has promoted the further reform of teaching methods. Through the combination of traditional educational content and teaching methods with digital technology, with the help of computers, Internet, mobile devices and other tools, the digitalization of teaching resources, the online teaching process and the personalized learning methods are realized.

Digital education provides students with more flexible and personalized learning methods, and promotes the cultivation of students' independent learning and innovative ability to cope with the rapidly changing learning and career needs in the information age.

2.4 The digital transformation of engineering education

High-quality engineering talent is an important internal driving force to promote the development of a country's manufacturing industry. The digital transformation of manufacturing industry not only puts forward new requirements for industrial development, but also puts forward new requirements for the training of engineering talents. The digital transformation of manufacturing industry needs a large number of compound talents who know both manufacturing knowledge and digital knowledge. Therefore, engineering education in the new era must cultivate new engineering talents with both professional and digital skills.

In the field of engineering education, the digital transformation of education has played an important role in cultivating new engineering talents, which is mainly reflected in the following aspects.

In the setting of disciplines, a number of "new engineering" majors have been set up to meet the major strategic needs of the country and the needs of industrial development, such as intelligent manufacturing engineering, artificial intelligence, intelligent construction, etc., in order to optimize the traditional professional structure and train talents leading the development of future technologies and industries in advance. In addition, the construction of new engineering also emphasizes the intersection and integration between different disciplines. It is mentioned in the "New Engineering Construction Route (Daya Action)" that the construction of new engineering should promote the cross-composition of existing engineering, the cross-integration of engineering and other disciplines, the extension of applied science to engineering, and the formation of new interdisciplinary majors.

In the teaching organization mode, the new engineering promotes the cross-integration of disciplines, promotes the integration of science and technology, the cross-engineering, and the penetration of industry and literature, breeds cross-professional, and promotes the cross-faculty, cross-disciplinary and cross-professional training of engineering talents. At the same time, it breaks the traditional subject-based college setting and establishes the College of Future Technology and the College of modern industry.

In terms of curriculum setting, relying on relevant majors, the introduction of "artificial intelligence", "big data technology" and other minor majors and related general education courses, encourage students to attend, master AI related knowledge and skills, and create more possibilities for their future development. In addition, interdisciplinary teaching contents such as "big data" and "artificial intelligence" are added to the professional courses of traditional engineering majors.

In terms of teaching resources, digital education uses the network platform to provide a wider range of learning resources, so that students can have access to more high-quality teaching content. Students can learn professional knowledge such as computer programming and network security through online courses, which is of great significance for the training of new engineering talents. Digital education breaks the restrictions of time and space, and students can learn according to their own needs and interests, regardless of geographical location and time. The digital interactive platform provides a platform for students to interact with teachers and classmates in real time. Through online discussion, online homework correction and other means, students can understand and apply the knowledge more deeply. Through group projects and forum discussions and other student cooperation, improve the teamwork ability and innovation awareness of new engineering talents.

At present, China has made a lot of efforts in promoting the digital transformation of engineering education, focusing on the training of talents in various manufacturing professions, but there is still a big gap between the needs of promoting the transformation of digital manufacturing. In the future, China will continue to adjust and optimize the professional curriculum of higher education in a timely manner according to the changes in the demand for vocational skills due to the digital transformation of the manufacturing industry, and promote the digital transformation of engineering education by appropriately extending the academic system, setting up dual-major bachelor's degrees, and encouraging manufacturing and digital-related undergraduates to apply for master's degrees in each other's majors. Train the engineering talents needed for the transformation of manufacturing industry.

3 The reform and practice of digital transformation of engineering education in

China

In order to cultivate the outstanding engineering talents needed to adapt to the digital transformation of China's manufacturing industry, China has actively carried out the excellent engineer training action.

In 2010, the Ministry of Education launched the "Excellence in Engineering Education and Training Program", that is, Excellence Program 1.0, proposing that for the industry, the world and the future, "train a large number of high-quality engineering and technical talents with strong innovation ability and adapt to the needs of economic and social development, and lay a solid human resource advantage for building an innovative country, realizing industrialization and modernization." We will strengthen our core competitiveness and overall national strength. The first batch of 61 universities, including Tsinghua University, Beijing Jiaotong University, University of Science and Technology Beijing, Tongji University and Shanghai Jiao Tong University, participated in the program to cultivate various types of high-quality engineering and technical talents, vigorously reformed the curriculum system and teaching forms, and established a curriculum system based on engineering innovation ability and practical ability.

In 2016, China joined the "Washington Accord", and China's higher engineering education was formally integrated with the international community. Then, in order to adapt to the new round of scientific and technological revolution and industrial change, centering on the national strategy and development needs, the Ministry of Education accelerated the comprehensive reform of higher engineering education and opened the 2.0 excellent engineer training stage focusing on the construction of new engineering. Launched the "Fudan Consensus", "Tian Da Action" and "Beijing Guide", Specific improvement measures are proposed from the aspects of carrying out new engineering research and practice, establishing new concepts of engineering education, innovating the organization mode of engineering education and teaching, perfecting the multi-subject cooperative education mechanism, strengthening engineering teachers' engineering practice ability, perfecting the innovation and entrepreneurship education system, deepening international exchanges and cooperation in engineering education, and building a new engineering education quality assurance system. At this stage, a total of 194 universities implemented the "Excellent Engineer Education and Training Program", a total of 433 undergraduate majors and 126 graduate level subject areas joined the excellence program.

In 2022, China began to pilot the construction of the National Institute of Excellent Engineers, aiming to accelerate the training of a large number of excellent engineers supporting the high-quality development of China's manufacturing industry, and strengthening the digital skills of engineering talents has become an important content of current and future Chinese engineer training. Many universities in China, especially those with expertise in engineering, have carried out the pilot and exploration of the digital transformation of engineering education, and accumulated certain experience. This chapter will introduce and summarize the training experience of engineering talents in China's typical universities from the aspects of talent training objectives, curriculum setting, practical training, teacher team construction, campus environment construction and so on.

3.1 The personnel training objectives

The requirements for engineering talents in the era of digital economy are mainly reflected in three levels: professional knowledge, digital skills and comprehensive ability. Professional knowledge includes not only the knowledge and skills of this major, but also the cross-professional knowledge and skills related to solving engineering problems of this major. Digital skills are essential skills for future engineering talents. Although the degree of mastery of digital skills varies by profession, comprehensive competence will become more important in the digital economy due to the increase in cooperation and communication. From the perspective of the case universities, the emphasis on the three levels of training goals have their own emphasis, and set the corresponding training goals.

The engineering talent training goal of the School of Engineers of Zhejiang University reflects the comprehensive requirements for excellent engineers, aiming at cultivating high-level engineering talents with profound theoretical foundation, professional skills, innovation ability and comprehensive quality.

The College of Engineers aims to cultivate outstanding engineers at the master and doctoral level, and takes the requirements of leading enterprises in the service industry for future engineering talents as the training standard. It not only needs to have a solid and broad basic theory and in-depth systematic expertise, but also needs to have the ability to solve complex engineering and technical problems, especially the "stuck neck" problem and the ability to innovate engineering and technology. But also with lofty ideals and beliefs, national feelings, engineering ethics and other comprehensive qualities, students can become a leader in their industry several years after graduation. It also emphasizes the cultivation of global strategic vision, good at solving complex engineering and technology problems and "stuck neck" problems, highlighting engineering and technology innovation ability, dynamic adaptability and other key abilities and qualities.

Huazhong University of Science and Technology (HUST) combines high-level talent training with the country's major needs in the establishment of engineering talent training goals, and is committed to cultivating students into senior engineering and technical talents with scientific, engineering and humanistic qualities, basic engineering knowledge, research and application ability, engineering practice ability, teamwork ability, innovation consciousness and international vision.

For example, the training objectives of the School of Mechanical Engineering can be summarized as follows: first, in terms of knowledge, it should have a solid and broad theoretical foundation and systematic in-depth professional knowledge in the field of mechanical engineering; Second, in terms of ability, we should have the spirit of scientific and technological innovation and the ability of independent research, have a keen insight into new technologies, and be able to lead the enterprise to continue to advance in technological progress and technological innovation, and continue to promote the technological progress of the enterprise; Third, in terms of quality, we should have relatively professional leadership, organizational skills and communication skills, unite and lead the R & D team of the enterprise, realize the organizational innovation of the enterprise, and have the ability to adapt to the market and reform the production and development of the enterprise.

3.2 The personnel training mode

In the field of engineering education, the digital transformation of education is not only the innovation of teaching methods and technologies, but also a profound reshaping of talent training system. With the acceleration of the digital transformation of the manufacturing industry, the traditional engineering education and training model has been unable to meet the needs of the society for innovative, composite and applied talents. Therefore, building a talent training system to adapt to digital transformation has become the most important thing in higher education reform. Case study universities explore innovative talent training models from undergraduate and postgraduate levels respectively.

3.2.1 Innovative undergraduate's talent training mode

In terms of the innovation of undergraduate talent training mode, the case universities mainly carry out systematic talent training reform by setting up top-notch innovative talent training plan and implementing college system, so as to explore a new path for undergraduate talent training.

Tsinghua University takes the opportunity of the "Strong Foundation Program" to set up five physical colleges on campus, namely, Zhili, Weiyang, Tanwei, Xingjian and Rixin. As the talent training units of the Strong Foundation Program, Tsinghua University is fully responsible for the talent training and management of the students of the Strong Foundation Program, so as to discover and cultivate innovative talents who can make future contributions to the basic research and scientific and technological innovation of the country. In engineering education, we strive to build a "generous foundation - engineering practice - exploration and research" integration training system.

Among them, the innovation in the training mode of the School of Integrated Circuits is an excellent representative of the reform of engineering education in Tsinghua University. Integrated circuit is a typical interdisciplinary discipline, which has the characteristics of basic disciplines such as physics, chemistry, material science and related engineering disciplines such as electronic information and mechanical engineering. The College of Integrated Circuit of Tsinghua University adopts the mode of combining the college training with the class training. In the major training, the first two years of undergraduate study will be related to electronic information courses, the last two years will involve integrated circuit related courses, adhere to broad caliber, thick basic training.

In addition, Weiyang College, which is set up by Tsinghua University to train students under the "Strong Foundation Programme", provides undergraduate training in accordance with the "Science + engineering" dual bachelor's degree. Students who meet the requirements can obtain a basic science degree in mathematics and physics (Bachelor of Science) and a bridging degree in engineering (Bachelor of Engineering). In addition, the School of Integrated Circuits also proposed the "1+N" joint mechanism for the first time in China, "1" refers to the School of Integrated Circuits, and "N" is the interdisciplinary integration. The School of Integrated Circuits of Tsinghua University will actively innovate in the aspects of teacher recruitment mechanism and organized scientific research, and set up cross-research centers with related departments to jointly promote interdisciplinary integration.

Shanghai Jiao Tong University established Zhiyuan College earlier, implementing the reform of "college system, tutor system and credit system", and is committed to cultivating new leaders with critical thinking, knowledge integration ability, communication and collaboration ability, multi-cultural understanding ability and globalization career, so as to meet the needs of the country's future science and technology and economic and social development for top talents.

Zhiyuan College manages the training of top talents in basic disciplines of the whole school, and has implemented the "Zhiyuan Honor Program" for top 10% students of the whole school since 2014, practicing the education concept of "four in one": value guidance, knowledge exploration, capacity building and personality cultivation. The exploration has formed a top-notch talent training system guided by "mission + curiosity" and "academic interest cultivation + scholar identity".

The "Zhiyuan Science Honors Program" offers six disciplines in mathematics, physics, life science, computer science, chemistry and biomedical science, which are scattered in the engineering departments of the university. Adhering to the excellent teaching tradition of Shanghai Jiaotong University with "high starting point, thick foundation, strict requirements, emphasis on practice and innovation", the University has formulated a new training plan with reference to the philosophy and experience of world-class universities, and hired top international scholars to participate in the training process.

3.2.2 Innovative graduate student's talent training mode

In terms of the innovation of graduate talent training mode, many domestic colleges and universities have carried out active exploration in the training of professional masters, among which the project talent training mode has become an important choice for domestic colleges and universities to train professional masters, and has achieved positive results, and has been widely recognized and gradually promoted. Among them, Tsinghua University and Zhejiang University are the two universities that pilot the project system of master of engineering in China.

Since 2016, according to the principle of "facing national needs, supporting key projects, and strengthening quality control", Tsinghua University has allocated enrollment quotas according to projects, and actively explored the establishment of professional degree quality standards and evaluation systems. In 2018, the Innovation Leading Engineering Doctoral program was launched, the enrollment scale was expanded, and the training departments were expanded from the original eight departments to all 25 engineering departments. In terms of enrollment targets, the doctoral training program of innovation leading engineering includes not only industry leaders who have rich practical experience in engineering, have achieved outstanding results, and have presided over or participated in important engineering projects as backbone, but also technical entrepreneurs of scientific and technological innovation enterprises. By 2021, a total of 1,436 innovative leading engineering doctoral students have been admitted, all from national key industries or innovative enterprises, distributed in 25 engineering training departments.

The project is positioned to train leading talents in scientific and technological innovation with international advanced level, serve the national innovation-driven development strategy, and build a new pattern of training high-end engineering talents.

Major projects include the Guangdong-Hong Kong-Macao Greater Bay Area Project, key areas project, Advanced technology project, Southwest Region project, integrated circuit project, public health and health project, etc.

Relying on the College of Engineers, Zhejiang University has implemented the "project system" talent training mode since 2019, breaking the guidance mode of "one teacher, one apprentice" system, taking the project as the talent training unit, and conducting enrollment, training and management according to the project, in order to cultivate interdisciplinary, "advanced, sophisticated and lacking" talents.

At present, it has carried out enrollment and training around 23 "engineering degree postgraduate excellence training projects" such as "Advanced materials and high-end manufacturing" and "high-end integrated circuit chip design and manufacturing", which are urgently needed by the country, with a total of more than 1,500 people. The project faces the needs of the industry, adheres to the complex cross, and sets up a joint guidance and research team of graduate students led by academicians and other strategic scientists and high-level talents, brings together graduate students from different professional categories, and works closely with 1-2 leading enterprises in the industry to realize the organic linkage of talent training, scientific research, technology research and development, and achievement transformation.

For example, the "Advanced Materials and High-end Manufacturing" excellent engineer training project team carries out the research and development work of nickel-based single crystal superalloy in Tonglu, Zhejiang Province, which is urgently needed by the national strategy. Every year, nearly 30 engineering masters and engineering doctoral students from 4 different engineering degree categories such as electronic information, materials and chemical industry, machinery, energy and power are attracted to conduct cross-professional learning and "bottleneck" technology research. It not only strongly supports the development of the local new material industry, but also cultivates the quality of students' love for the Party, dedication and dedication in practice, and truly brings out a team of engineers with outstanding technological innovation ability and good at solving complex engineering problems.

3.3 Curriculum provision

At present, Chinese universities attach great importance to the cultivation of innovative and interdisciplinary talents, which requires students not only to have excellent professional ability, but also to have relevant digital skills and high comprehensive literacy. And the cultivation of these knowledge and ability is first reflected in the curriculum provision, through providing students with relevant courses to achieve the cultivation goal.

The Basic Industry Training Center of Tsinghua University is the largest engineering practice base in Tsinghua University. It undertakes the task of cultivating students' engineering practice ability and offers courses such as metalworking and electronic technology practice. The curriculum system of Tsinghua Engineering Training Center is divided into three parts: engineering literacy training, engineering ability training and innovation and entrepreneurship training. Each section has developed corresponding ability training programs according to the development needs of students. The curriculum integrates conventional manufacturing technology practice, advanced manufacturing technology practice, comprehensive quality training and innovative practice, attaches importance to teaching and educating people, and gives students comprehensive education in knowledge, ability and quality.

In addition, Tsinghua University has also participated in the digital construction of online courses, producing online courses such as "Mechanical Manufacturing Internship". Together with "School Online", the center focused on creating an online course of 15 practical training links in mechanical manufacturing practice. Not only that, the center will also put the above resources on the school's online video resources for students to learn. In addition, the center has also established a video center for engineering training courses, where video materials such as basic engineering courses and engineering culture courses are shared on the website.

In terms of general education, Shanghai Jiao Tong University implements the concept of integration of disciplines and integration of science and education, and establishes a curriculum system of general education. Carry out the reform of Datong Liberal education, build a basic and general curriculum system covering the knowledge structure groups of the four disciplines of material science, data science, life science and humanities, systematically comb out the knowledge association structure, break the disciplinary boundaries, guide students to explore problems with scientific thinking methods, and cultivate their independent thinking and judgment ability. Enhance social responsibility and sense of identity as a scientist to maximize development potential.

Guided by "more difficult, higher, deeper and wider", we have designed 42 Zhiyuan honor courses, opened 16 liberal arts and science permeable general courses, and set up "mathematical mathematics", "Chemical and biological medicine" and engineering subject groups. Establish a series of research-oriented courses, such as frontier exploration experiment course unit and cross-innovation course module.

3.4 Practical Training

On-campus practice is an important means to cultivate students' practical ability. By providing high-level experimental bases and organizing innovation and entrepreneurship practice activities, Chinese colleges and universities have carried out on-campus practice reform in various forms and with rich connotations, providing a good platform for students' practical ability cultivation from the internal level.

At the practical training level, Huazhong University of Science and Technology provides various experimental research centers for students, including the National Digital Design and Manufacturing Innovation Center, the National Engineering Research Center for Manufacturing Equipment Digitalization, the National Key Laboratory of Intelligent Manufacturing Equipment and Technology, and the Digital Equipment Industrial Design Laboratory of the School of Mechanical Science and Engineering of Huazhong University of Science and Technology, to provide guarantee for students' practice. In addition, various engineering education practice projects have been set up for students, including HUST-WPI engineering practice project, practical innovation experimental class, etc. Students have the opportunity to carry out cross-border internship practice through international exchange, and effectively improve comprehensive ability.

Beihang University has built a digital aircraft science and education cooperation platform, which provides an advanced platform for students to carry out engineering training based on industrial software, and promotes the deep integration of education and technology talents through the construction of science and education cooperation platform. Beihang University adheres to the integration construction of disciplines, platforms and teams, builds platforms, attracts talents and gathers teams in key directions, and builds more than 10 science and education collaboration platforms such as intelligent micro-nano public innovation Center, air-heaven integrated information network, and digital twin intelligent transportation system in different stages, providing hard support for sharing services for talent training, talent convergence and scientific and technological innovation.

Aiming at key fields such as aerospace, information technology, and life and health, the school strengthens the two-way interaction between education and teaching and scientific and technological innovation through the collaborative platform of science and education, highlights the characteristics of interdisciplinary integration, supports high-quality independent training of compound talents, improves the innovation efficiency of the whole chain of basic research, key technology and application verification, and cultivates new growth points in the discipline direction.

3.5 Construction of teaching staff

Excellent teaching staff is the key to cultivate excellent engineering talents. In the concrete practice of teacher team construction, Chinese colleges and universities have carried out effective practices in attracting high-level teachers, setting up on-campus teaching teams, strengthening teachers' teaching level, and attaching importance to the training of teachers' digital skills, so as to strengthen teacher team construction from both inside and outside the school. It has laid an important foundation for the training of high-quality talents.

In order to ensure the overall quality of teachers, the School of Mechanical Science and Engineering of Huazhong University of Science and Technology regularly carries out teaching training courses for new full-time teachers, imparts advanced educational concepts to teachers, improves curriculum ideological and political awareness and ability, and helps teachers master teaching skills. The College also actively organizes academicians and outstanding teachers to form a teaching team to teach undergraduates, and gathers superior teachers to offer courses such as introduction, hoping that undergraduates can broaden their horizons of study and research from the early stage of study, focus on future science and national needs, and cultivate their interest in study and research.

China University of Petroleum (East China) has specially set up a short-term digital skills teaching class for all teachers to help teachers master certain digital teaching skills. The workshop invites well-known experts or teams from inside and outside the school, focusing on hot and difficult issues such as AI technology and application, project-based teaching, wisdom curriculum construction, curriculum ideological and political integration, and teaching innovation strategies, and adopts a combination of online and offline, centralized training and independent electives to carry out various forms of teaching development activities. The digital literacy and skills of teachers should be further improved to promote the reform and innovation of education and teaching in schools.

3.6 Campus environment construction

Education digitization has become an important trend in the current education and teaching reform, which has an important impact on the means and objectives of personnel training. Strengthening the construction of digital facilities is the basic condition for promoting the digitization of education. Colleges and universities actively invest in promoting the construction of digital facilities, providing better digital conditions for talent training. All colleges and universities are actively building digital campuses and meta-universe campuses to provide a more intelligent digital campus environment for students' learning, teachers' teaching and school management.

Tsinghua University has established a national experimental teaching demonstration center for virtual simulation of digital manufacturing system to strengthen the construction of digital teaching resources and open sharing of information. The center has built software remote access platform, teaching resource access platform and cloud platform to provide open resource sharing. The construction of the virtual simulation experiment platform optimizes the experimental teaching resources, improves the teaching and management ability of the teaching team, and improves the informatization level of experimental teaching management and support services.

In addition, in June 2022, Tsinghua University also launched the first meta-universe recruitment double selection meeting. Through the introduction of meta-universe technology, creating a virtual recruitment platform on the cloud provides an immersive recruitment service experience for students and employers. In the meta-universe virtual world, students can set character images, manipulate virtual characters in an immersive way, roam the exhibition halls of enterprises, watch promotional videos, deeply understand the job information of different enterprises, interact with recruiters online in the form of video and voice, and share and deliver resumes in real time through shared screens. The form of the meta-universe recruitment double selection meeting is novel and interesting, convenient and efficient, and in the severe and complex situation of the epidemic, it restores the real recruitment scene, helps the employer to efficiently match talents, and improves the interview efficiency.

Zhejiang University has created an intelligent network platform of "Learning in Zhejiang University". By supporting the whole teaching process of teachers and students from educational affairs course selection, platform course construction, live teaching, classroom interaction, homework grading, intelligent analysis to intelligent examination, an open-loop education system has been built.

"Learning in Zhejiang University" has realized the integration of curriculum platform and classroom teaching, landing the current mainstream mixed teaching mode, and providing strong support for teachers and students to improve teaching efficiency and educational administration departments to improve management effectiveness. By promoting the construction of teaching space, we have initially built a full-scene teaching space with knowledge graph as the core, integrated smart classroom, intelligent cloud classroom, and operation management system, and built an all-weather online and offline, synchronous and asynchronous teaching space to meet the various teaching application needs of teachers and students.

In addition, "Learning in Zhejiang University" can also obtain real-time data on the use of classroom equipment, personnel status data, teaching process data and fault alarm maintenance data through the smart classroom cloud management and control platform, and automatically monitor the operating status of the system to achieve intelligent management and control of equipment.

4 Challenges faced by the digital transformation of engineering education in China

In the existing practice of digital transformation of engineering education in China, many colleges and universities have carried out a variety of reform attempts based on the actual situation and teaching characteristics of their own schools. But at the same time, it can also be found that there are still some problems to be solved in the process of promoting the digitization of engineering education in Chinese universities. This chapter will summarize the challenges faced by the digitization of engineering education in China from three aspects: the low degree of digital integration of curriculum, the weak digital skills of teachers, and the lack of professional application scenario teaching of digital skills.

4.1 Low degree of curriculum digital integration

In the aspect of curriculum provision, most colleges and universities have added the corresponding digital technology content. First, by transforming traditional courses, digital and artificial intelligent-related content is added to traditional courses. The second is to add new courses related to digital technology to enhance students' digital skills. However, from the perspective of practical development, the opening of these two types of courses has encountered the problem of low digital integration.

First, in the transformation of traditional curriculum, the knowledge system combining traditional knowledge or curriculum with digital technology is not mature, and matching teaching materials are rare. Moreover, the traditional engineering teachers still do not understand the digital technology or can not mature the use of the situation, which brings great challenges to the establishment of the integration of the two courses.

Second, in the newly established digital courses, most of the new courses related to digital skills are offered by teachers from the school of Information or computer science, and the combination with traditional engineering majors is not enough, so it is difficult to train students to apply digital technology and integrate professional technology.

In addition, due to the rapid development of digital technology, the curriculum provision and content of some colleges and universities may lag behind the latest technological trends. This results in a certain disconnect between what students learn and their actual needs. In general, the low degree of curriculum digital integration in curriculum reform is a major problem that cannot be ignored.

4.2 Teachers' inadequate digital skills

Building a team of teachers who can adapt to the digital requirements of the new era is the inevitable requirement of the digital transformation of engineering education.

The research colleges and universities mainly strengthen the construction of teachers by improving the teacher evaluation system, taking teachers' ethics as the first standard, adhering to the system of teaching undergraduates, and improving the standards of education and teaching quality and talent training effect in teacher evaluation and award evaluation. At the same time, the digital skills of teachers are generally weak in the construction of teachers. The lack of teachers' digital skills is mainly manifested in three aspects: teachers' digital knowledge reserve, the application ability of digital technology, and the analysis and guidance of digital teaching.

First of all, some teachers lack sufficient digital knowledge and skills to effectively teach digital-related courses and it is difficult to carry out integrated teaching in combination with their majors. This may lead to teaching content out of touch with the latest technological developments, affecting students' digital ability cultivation.

Secondly, in the specific application of digital technology, many teachers are not skilled enough to master the latest educational technology tools such as online collaboration platform, virtual simulation software, intelligent teaching system. This makes it difficult for them to take full advantage of digital tools when designing courses and organizing teaching activities. For example, many colleges and universities have been equipped with advanced digital teaching facilities, but the actual utilization rate of teachers is not high due to the lack of effective technical training.

Moreover, the use of big data and artificial intelligence to conduct targeted learning situation analysis and personalized learning guidance for students is an advanced stage of the digital transformation of engineering education, but it puts higher requirements on teachers' data analysis ability. At present, many teachers lack deep digital literacy, and it is difficult to extract valuable information from massive learning data to guide teaching practice and evaluate student learning effectiveness.

4.3 Insufficient teaching of professional application scenarios for digital skills

In the process of promoting the digital transformation of engineering education, research universities have taken many measures and made a lot of progress in the reform of teaching mode and mode. For example, in the teaching methods, the use of online teaching, mixed teaching, project teaching and other methods to improve the traditional teaching methods. In terms of teaching mode, through the construction of smart classrooms, smart classrooms, and virtual simulation experiments, students' learning autonomy, real-time evaluation and feedback, and personalized teaching strategies are realized.

In general, it promotes the improvement of digital teaching level, but it still faces the problem of insufficient teaching of professional application scenarios of digital skills. Although many engineering education courses introduce digital tools and technologies, they often stay in the theoretical explanation and simple operation level, and lack practical cases that are deeply integrated into specific engineering projects.

For example, although students in case colleges and universities have learned the basic operation of Computer Aided Design (CAD) software, they fail to deepen their understanding and application of these skills by solving practical engineering problems. As a result, skill mastery remains superficial, and it is difficult to form the ability to solve practical complex problems. There is a disconnect between the theory and practice of digital skills cultivation, which directly affects the quality of engineering education and the cultivation of students' practical ability, and limits the competitiveness of graduates in the future workplace.

In addition, some universities lack practical training platforms that synchronize with cutting-edge technologies in the industry, and it is difficult to meet the teaching needs of students in application scenarios that keep pace with The Times. The rapid development of engineering technology requires that the content of engineering education in colleges and universities must keep up with the pace of The Times. However, in reality, the updating of teaching resources in colleges and universities often lags behind the upgrading of technologies, and it is difficult to provide a teaching environment with application scenarios based on cloud computing, big data, artificial intelligence and other latest technologies. As a result, students find that there is a gap between the skills they have learned and the actual needs of the industry after graduation, and they need to spend extra time and effort to relearn.

5 Countermeasures and suggestions for the digital transformation of engineering education in China

Based on the above challenges faced by digital engineering education in China, this chapter will put forward corresponding countermeasures and suggestions from the following three aspects.

5.1 Strengthening the construction of integrated teaching materials and standardizing the frontier knowledge system

Strengthening the construction of integrated teaching materials and standardizing the frontier knowledge system is the key to strengthen the digital integration degree of engineering education curriculum. The field of engineering technology shows a trend of interdisciplinary and comprehensive development. In order to match the development of new digital courses, it is urgent to develop a batch of integrated teaching materials that contain both traditional engineering knowledge and new digital knowledge. The construction of integrated teaching materials needs to integrate multiple resources to build a set of standardized frontier knowledge system.

In the construction of integrated teaching materials, first of all, it is necessary to integrate the wisdom of education experts, engineering industry leaders and first-line engineering teachers to jointly build an integrated teaching material system. This system should break the boundaries of traditional engineering education, integrate computer science, information technology, management and other fields of knowledge, and cultivate students' comprehensive literacy and interdisciplinary ability. For example, developing textbooks such as "Chemical Engineering + AI" and "Mechanical Engineering + AI". These textbooks are not merely a patchwork of knowledge from different disciplines but rather new content formed through the deep integration of knowledge across disciplines. They provide students with the latest advancements and examples of the integration of professional knowledge with AI.

Secondly, we should actively use modern information technology such as virtual reality (VR) and augmented reality (AR) to innovate teaching materials. Modern information technology provides infinite possibilities for the innovation of teaching materials. Through the VR, AR and other technologies, the development of immersive, interactive digital teaching materials can increase students' interest in learning and engagement. At the same time, an online teaching material platform is established to realize the real-time update and remote access of teaching materials, so that students can learn anytime and anywhere. For example, virtual teaching cases can be developed to present chemical reaction processes in the chemical engineering field or manufacturing processes in the mechanical engineering field through VR, AR, and other technologies. This allows students to immerse themselves in the realization process of engineering products, enhancing their understanding of engineering.

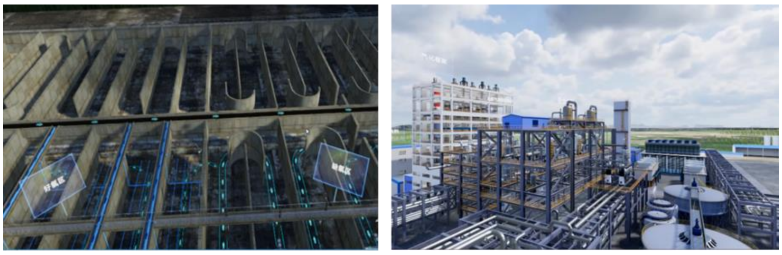

Figure 2 Virtual "Wastewater Treatment Plant" (left) and "Coal Gasification Unit" (right) for teaching purposes

(Source: East China University of Science and Technology)

Moreover, the construction of integrated teaching materials should also pay attention to its practicability and practicability. Practice is the litmus test of theory. In the construction of integrated teaching materials, we should pay attention to practical application, add case analysis, project practice and other contents. Cooperate with enterprises to develop practical teaching materials, integrate advanced technology and management experience of enterprises into teaching materials, and improve students' practical ability and employment competitiveness.

A set of standardized frontier knowledge system is the basis of teaching and the framework of teaching materials development. Under the background of digital transformation, the new knowledge system must keep up with the development trend of science and technology and update the teaching content in time. Textbook developers should pay close attention to the latest research results and technological developments in the field of engineering technology, and incorporate cutting-edge knowledge into textbooks in a timely manner.

Secondly, in order to ensure the timeliness and accuracy of the knowledge system, the updating mechanism of the knowledge system should be established. A dedicated group is set up to regularly evaluate and adjust the content of teaching materials to ensure that they keep pace with the development of the engineering industry. At the same time, teachers and students are encouraged to participate in discussions and suggestions on updating the knowledge system to form an open and inclusive atmosphere for updating.

5.2 Enhancing interdisciplinary doctoral training to build a preparatory teacher team with digital skills

Strengthening the interdisciplinary doctoral training can train a team of preparatory teachers with digital skills, which is a desirable measure to strengthen the construction of digital teachers in the future.

In the face of the current problem of weak digital skills of teachers, in addition to strengthening the digital ability of in-service teachers, the interviewed teachers also proposed that the level of digital skills of teachers can be improved by directly introducing cross-disciplinary talents with both digital skills and professional knowledge. Although these talents are few, under the current background of widespread influence of digital technology, many reserve talents such as engineering doctoral students have begun to pay attention to and improve their digital skills, and some have already possessed the ability to integrate professional and digital technology, and can actively explore and introduce these talents.

On the other hand, doctoral students are powerful reserve talents for future engineering teachers in universities, and universities, as their nurturers, can also take the initiative to contribute to the construction of preparatory teachers with digital skills by strengthening the training of interdisciplinary ability and digital literacy of engineering doctoral students. Actively carry out digital skills training for doctoral students, so that they can master digital skills related to their majors. Take digital skills as a necessary skill for doctoral students in engineering, so that they have the corresponding knowledge and ability before becoming teachers.

For example, courses related to digital teaching are set up, and compulsory courses for engineering doctors are added. Such courses cover engineering, digital technology, management and other fields, focusing on the combination of theory and practice to improve the practical application of emerging digital technologies.

In addition, it is possible to provide doctoral students with more professional multidisciplinary guidance by establishing a tutor team and forming a team of tutors with engineering and information science backgrounds to jointly supervise doctoral students. Conduct digital skills training workshops for doctoral students. Digital skills training workshops for prospective teachers are held regularly, covering the use of online education platforms, data analysis software applications, and virtual and augmented reality technologies. Through practical exercise and case analysis, improve the digital technology application ability of doctoral students and strengthen the construction of preparatory teachers.

5.3 Providing an enterprise-class training environment to enhance students' application level of digital skills

Providing enterprise-like training environment to improve students' application level of digital skills is helpful to solve the problem of insufficient teaching of professional application scenarios of digital skills.

First of all, colleges and universities should strengthen the construction of digital teaching facilities. Increase the investment in digital teaching equipment, adopt advanced teaching technology and means to carry out teaching, and exercise students' digital skills. Such as the construction of intelligent classrooms, equipped with advanced data analysis tools, etc., to provide strong support for digital teaching.

At the same time, colleges and universities can also work together with enterprises to establish internship and training bases through school-enterprise cooperation and provide enterprise-like training environment. To expose students to and apply digital technologies in a practical work environment. For example, enterprises can set up data analysis projects, software development projects, etc., so that students can practice digital skills in the projects, from data collection, cleaning, analysis to the presentation of results, and master the methods and tools of data analysis; Enhance students' programming skills and project management skills in software development projects.

In addition, a job rotation system is established to allow students to accumulate digital skills in different positions, understand the business needs and digital technology application scenarios of different departments, broaden their horizons, and enhance comprehensive digital skills.

For example, Beihang University provides students with more learning resources and communication opportunities by building online learning platforms, virtual simulation LABS, and collaborative cloud platforms for science and education, so that students can practice and apply knowledge in a digital environment.

In aerospace majors, students can use the industrial design simulation cloud platform, such as the new generation of all-digital aircraft science and education collaborative innovation platform jointly built with the national Virtual Teaching and Research Office, Virtual Simulation Alliance, and virtual simulation Experiment Demonstration Center, which has invested nearly 5 million yuan and brought together 44 software from 12 units. More than 200GB of simulation and model data per year. These resources and equipment support students' professional practice, provide students with a platform for practical operation and practical experience exchange, and cultivate their professional competence in the digital environment.

Figure 3 Enterprise-Like Simulation Training Center in Beihang University (Source: https://news.buaa.edu.cn/info/1002/58410.htm)

6 Conclusions

At present, in the context of a new round of technological revolution and the transformation and upgrading of the manufacturing industry, it is a major strategic task for China to promote the digital transformation of engineering education, deepen digital empowerment teaching, and accelerate the training of high-end engineering and technology talents with digital literacy to achieve self-reliance in high-level science and technology.

Chinese universities have not only improved the digital level of engineering education, but also enhanced the quality and efficiency of engineering education, and promoted the cultivation of talents with digital skills and knowledge through the innovation of personnel training objectives and systems, curriculum provision, practical training, faculty construction and campus environment construction. Some results have been achieved. The practical exploration of the digital transformation of engineering education in China not only reflects the innovative role of contemporary information technology in the field of education, but also shows China's positive response to the challenges of the global digital education wave.

However, the digital transformation of engineering education is a process of continuous evolution. At present, China's engineering education reform still faces multiple challenges, such as low degree of curriculum digital integration, weak digital skills of teachers, and insufficient teaching of professional application scenarios of digital skills.

In the future, China engineering education should continue to deepen the cooperation with the industry, through strengthening the construction of integrated teaching materials, training interdisciplinary doctoral students, providing enterprise-class training environment and other measures to implement digital empowerment teaching. Strengthen data-driven personalized teaching to cultivate digital knowledge and skills of engineering students, thus further improving the quality and competitiveness of engineering education in China.

The digital transformation of engineering education in China needs the joint efforts of government, schools, enterprises and all sectors of society. Through continuous exploration and practice, Chinese universities will cultivate more outstanding engineers with digital skills, international vision, innovative spirit and practical ability, providing solid talent support for the country's scientific and technological innovation and industrial upgrading.

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