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Teaching Practice Exploration based on Digital Twin Technology

-- Taking Industrial Robot Integrated Application Technology Course as An Example

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Abstract: This paper studies the application of digital twin technology in practical courses, aiming at the pain points that the teaching of industrial robot application practical courses relies heavily on the number of practical training sites and equipment, and it is difficult to match the actual production. This paper focuses on the online digital simulation of key equipment, production products, processing technology and typical production lines in the application scenarios such as school training site and factory workshop through the twin technology, so as to build the digital twin training platform, restore the typical work tasks of enterprises, support the practice of online or online offline mixed digital teaching, and deepen the collaborative education between schools and enterprises.

Keywords: Digital twin technology, Twin training platforms, Mixed online and offline teaching.

1. Introduction

In recent years, with the cluster breakthrough of 5G communication, artificial intelligence, big data analysis, Internet of Things, cloud computing and other technologies, the application of intelligent technology in the industrial field continues to deepen. Industry 4.0, with "intelligent manufacturing" as its main feature, is about to complete the energy storage stage of quantitative change. Thus, a highly flexible, humanized and digital model and system of social production service is formed [1]. "Digital twin" is one of the core technologies implemented by Industry 4.0 [2], also known as "digital twin", which is a digital copy of physical objects and their behaviors. It can simulate, predict and optimize the running state of objects [3], and has features such as high-fidelity, real-time interaction, virtual-real symbiosis and deep insight. It will reconstruct the living environment of human beings in the future [4]. With the innovative application of digital twinning workshop and product digital twinning in intelligent manufacturing [5-6], digital twinning technology also provides new development opportunities for the deep integration of industry, university and research and the innovative development of practical teaching. With the support of this technology, online digital simulation can be carried out on key equipment, production products, processing technology, production line and even the whole workshop in the application scenarios such as factory workshop, training classroom, practice base and training center [7].

At present, the theoretical exploration, technical development and practical application of digital twin education have begun at home and abroad. Toivonen et al. built the digital twin of flexible manufacturing system as an engineering education and learning environment to help learners get familiar with the automatic production system before the operation of physical equipment, and achieved good learning effect [8]. Nikolaev et al. carried out project-style teaching of small UAV design based on digital twin [9]. Based on the experiential learning circle theory, David et al. used digital twin technology to assist in learning flexible manufacturing systems and achieved positive results [10]. Domestic scholars have also actively applied twinning technology to explore the construction of cognitive digital twinning, immersive architectural model twinning environment, digital twin platform and other support systems to enhance experience. However, few researchers apply twin technology into the whole teaching process to explore the school-enterprise collaborative teaching practice of digital twin application.

2. The Significance of Application of Digital Twin Technology in Teaching Practice

2.1. Theoretical Significance

Through visualization, flexible simulation and innovation incubation of digital twin technology, practical teaching can be enabled, which can promote the development of practical teaching in colleges and universities to the direction of experiential, open and sharing. Through digital twin technology, the cooperation between universities and enterprises can be deepened, so that the cutting-edge technologies between teachers and students of universities and enterprises can be seamlessly connected in real time, so that teaching can fully penetrate the intelligent factories and workshops of enterprises, promote the digital transformation of universities and enterprises, and realize the innovative digital drive of teachers and students of universities and engineers of enterprises based on the integration of virtual and real.

2.2. Practical Significance

Through the joint development of twin resources by universities and enterprises, it can promote college teachers to better face the practice of enterprises, accumulate

enterprise experience and improve the comprehensive quality. With limited resources, students can learn relevant knowledge through the simulation of the twin model, and synchronize the virtual training process to the corresponding physical entity, so as to provide students with greater fault tolerance and security, but also can visualize the enterprise experience, process habits and other unimageable content, providing a digital auxiliary means for the cultivation of interdisciplinary talents.

2.3. Research Value

The digital resources developed by twining technology and its application in teaching are in line with the development spirit of digital education in China. The application of twinning technology can solve the problem that the teaching of practical courses such as industrial robot is limited by practical training equipment and it is difficult to connect with the actual production. In the twin environment, it can design, debug and backtrack the control scheme, present the control effect in the animation way, and intuitively judge the control logic problems, breaking through the difficulties of traditional teaching that "program design is not intuitive and debugging experience requirements are high".

3. Exploration on Innovative Teaching Practice of School-enterprise Collaborative Education Based on Digital Twin Technology

This paper is based on the perspective of production and education, following the student-centered teaching concept, guided by the Master teacher supported by "National high - level talent special support plan" and the national teachers' teaching innovation team, relying on the state-level advanced manufacturing cluster (regional pillar industry) production-education alliance, state-level science and technology innovation service platform, and state-level productive training base, School-enterprise cooperation application of digital twin technology integrates the practical training equipment of the school's robot course with the application scenario cases of the alliance enterprises, builds the digital twin practical training platform, integrates the digital resources of the online course platform, creates a "ubiquitous" teaching new ecology, and explores the school-enterprise collaborative education innovation teaching practice based on digital twin technology.

3.1. The Points That Digital Twin Technology Can Be Combined in Teaching Practice

3.1.1. Twin Technology Presents the Real Situation of Enterprises, Deepening School-Enterprise Cooperation and Promoting Collaborative Education

Relying on the three national platforms of “Production, Research, Education” to implement collaborative education. enterprise mentors and teachers of the production-education alliance together as a pair, make joint lesson preparation and collaborative teaching, apply digital twin technology to restore the real process and production line equipment of the alliance enterprise, simulate the production situation under different situations and conditions, visualize the enterprise experience, process habits and other contents that cannot be visualized. Cooperate to develop twin teaching materials, videos, animations, etc., and update loose-leaf teaching materials to ensure the safety of students while experiencing the real situation of the enterprise. (Figure 1)

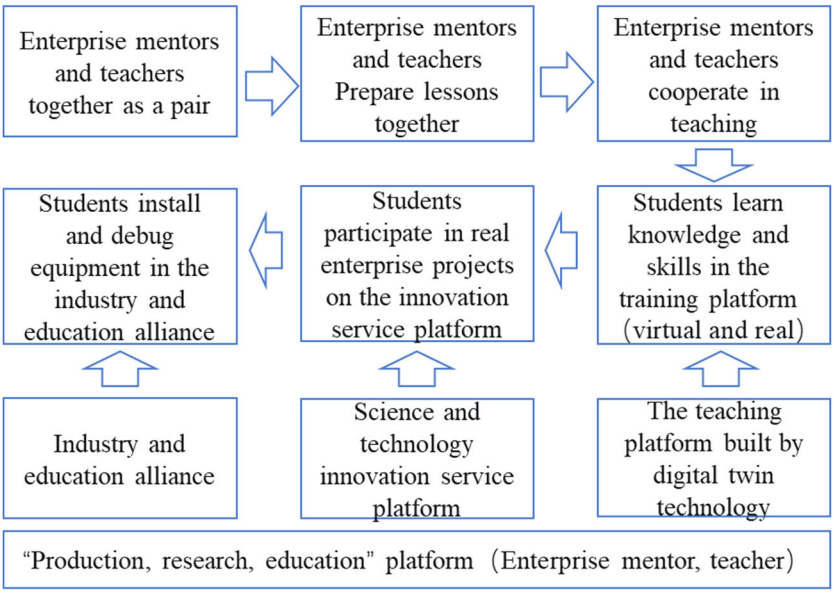

Figure 1. School-enterprise cooperation in education

3.1.2. Twin Technology Integrates Digital Teaching Resources to Create an Unlimited Teaching platform

Digital twin technology is adopted to build a digital training platform that is the same as the campus training platform. Combined with digital teaching resources such as videos and animations on the online course platform, students can conduct independent exploration, cooperation and communication, online training and automatic score keeping through the task guidance of loose-leafed textbooks and the link of two-dimensional code. In post-epidemic remote teaching, teachers can conduct demonstration operations on both real and digital training platforms. Online students integrate into offline classes by using the teaching tracking system composed of "monitoring camera + mobile camera

monitoring cloud head + remote server", and conduct follow-up training on digital platforms, real-time interaction with offline groups, and real-time evaluation by teachers and corporate mentors (Figure 2).

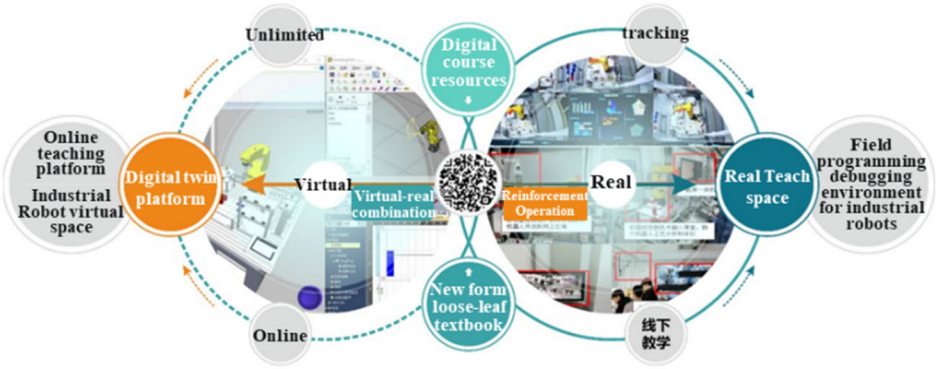

Figure 2. Twin platforms combined with virtual and real

3.1.3. Twinning technology realizes intelligent evaluation and supports dynamic optimization of teaching and learning

Digital twinning technology is applied to construct a twinning scoring system. When teachers and students run tasks and implement control procedures on digital twinning platform, they can automatically evaluate and score from the aspects of logic, rhythm, energy consumption, norms and so on, and immediately feedback the knowledge and skills learning results in stages, which supports the teaching process to be intuitive, evaluable and measurable, and improves students' self-understanding and teachers' evaluation dimension. For the teaching difficulties in the implementation of tasks, the twin model can be used to carry out panoramic backtracking, to help teachers observe and analyze teaching links from multiple perspectives, so as to optimize teaching activities.

3.1.4. Twin technology builds " Virtual Innovation space" to Support innovation and creative education

Twinning technology is used to seamlessly connect physical and virtual learning Spaces, creating an open "virtual Innovation space" based on digital twinning and breaking the limitations of traditional physical maker Spaces. As long as students master the design process and optimization method of twin workstations, they can connect real cases of enterprises in the twin platform, and carry out control design, virtual debugging and scheme verification of various types of digital twins without limitation of time and space, which greatly stimulates students' learning interest and innovation consciousness.

3.2. The specific process of twining technology in teaching practice

The teaching team, led by national famous teachers, builds a "trinity" production-education collaborative teaching base relying on the production-education alliance, the national collaborative innovation Center and the national training base, applies twin technology to build a digital ubiquitous teaching ecology, explores a new path of production-education collaborative teaching under digital twin, and promotes teaching reform in stages.

3.2.1. Build digital teaching ecology by relying on the platforms of “Production, education and research”

Relying on the national teaching innovation team of teachers, the three mentors of "enterprises, students and teachers" rely on the three platforms of industrial alliance, technology platform and training base to carry out collaborative teaching (see Figure 3).

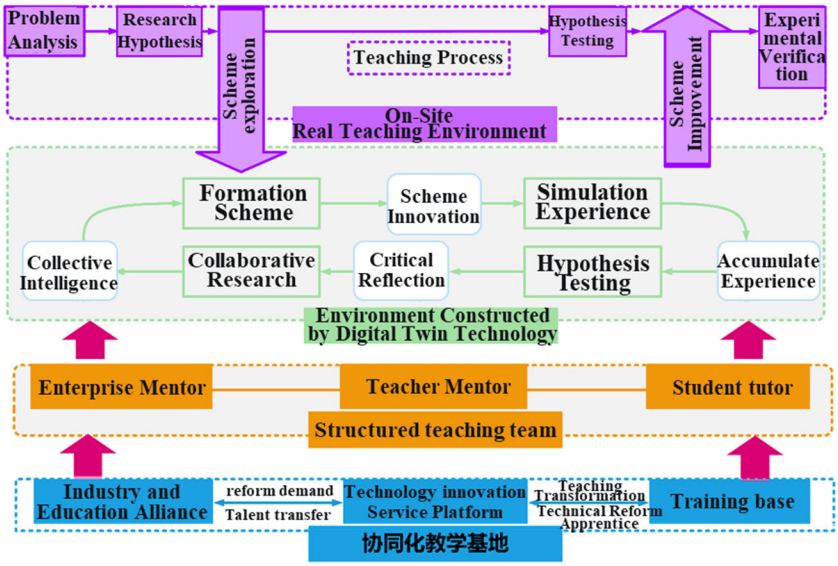

Figure 3. The Teaching Process based on Digital Twin Technology

The production-education alliance arranges part-time teachers for the course, provides teaching materials, cooperative teaching standards and resources for the enterprise, and establishes a workshop level digital twin model through the twining technology, which can contain all the details of the object in reality and its production planning and execution process. Relying on the national production training base, the digital twin technology is adopted to build a digital training platform identical with the real training platform, and the online course platform video, animation and other digital teaching resources are connected. Students can conduct independent exploration, cooperation and communication, and online training through the task guidance of the loose page textbooks and the link of the two-dimensional code, so as to make reserves for participating in the real projects of the platform. Relying on the state-level technology innovation service platform in the university, teachers enter the innovation platform to establish a studio, and the cultivated students enter the technical positions in the innovation platform studio, participate in the enterprise "machine replacement" real technical transformation project undertaken by the teachers, and convert the twin technology into the teaching case of the course, and transform the method, standard and team of technical transformation into the teaching support resources of the course.

3.2.2. Implement the new teaching process of digital twin according to the new teaching ecology

The twinning teaching mode organizes teaching according to "problem solution hypothesis, digital twinning simulation verification, practical test and application", and carries out classroom activities according to the process of "problem analysis → research hypothesis → observation and exploration → verification hypothesis → improvement scheme → practical application" (see Figure 3). First of all, based on the actual problems of the enterprise (twin presentation), sorted out the key points of knowledge and skills, and put forward solutions; Then, through repeated interaction with the digital twin environment to complete the simulation verification, embodied experience, wisdom accumulation to achieve program innovation; Finally, in the physical learning environment (training platform and innovation platform), the innovation solution is applied to the specific practice, the practical application effect is tested, the customer feedback is obtained, and the final decision is made whether to start the next round of program revision, program hypothesis and digital twin verification activities.

3.2.3. Promote practical teaching reform in stages Based on the Teaching Method Transformed by Digital Twin Technology

The first stage is to promote the digital twin transformation in the learning stage of curriculum theory and practical operation. Firstly, digital twin technology is used to digitialize, virtualize and intelligentialize all kinds of things in the real teaching space, including books, courseware, teaching plans and practical training equipment, etc., to build a digital virtual space (including programming methods, debugging and physical effects of actions are consistent) as well as all data information in the virtual teaching space. Through data-driven, modeling and simulation, abstract simulation, digital overlay into the real teaching space to produce an online hybrid scene based on the deep integration of virtual and real.

The second stage of enterprise project learning phase digital twin transformation. Firstly, the digital twin technology is used to digitize and virtualize the equipment structure, machine design, production and processing flow in the practical operation manual in the factory and workshop. All enterprise data and perception information in the constructed digital virtual real operation space is digitally superimposed into the real operation manual (loose-leaf textbook) through data-driven and simulation, so as to generate the online enterprise real operation scene based on the deep integration of virtual and real, so that students can "personally" perceive the working environment of the enterprise field production line.

The third stage is the digital twin transformation of makers and innovation education. Under the joint guidance of platform mentors and enterprise mentors, students can apply twin technology to carry out comprehensive enterprise technical transformation projects. Students can use virtual twin tools to analyze and modify, optimize and verify, realize their own creativity, and join enterprises in the design and production of enterprise smart factory and smart workshop. While injecting new vitality into digital teaching in colleges and universities, It also provides a new development path for the intelligent transformation and development of enterprises. This mode not only opens the door of intelligent manufacturing of enterprises, but also opens a new journey for the intelligent development of universities.

3.3. Practical Value and Experience

Compared with traditional teaching methods, by constructing a digital twin training platform and restoring typical work tasks of enterprises, industrial robot course teaching is limited by practical training equipment and difficult to connect with actual production pain points. Secondly, the twin platform can simulate the production conditions in different situations and conditions, conduct rehearsal and predict the results, effectively help learners avoid risks and provide greater fault tolerance. Finally, when providing interactive learning experience for learners, the twin platform or "twin workshop" can ensure the personal safety of learners, and can visualize the enterprise experience, process habits and other unimageable content in a more intuitive way.

The two practical modes proposed in this paper: the new teaching ecology created based on digital twin technology and the path of collaborative education achieved by connecting real cases of enterprises with the application of twin platform, can be popularized and applied to the teaching of all engineering practical courses, opening a new journey for the intelligent development of colleges and universities, and providing a new development path for the digital transformation and development of enterprises.

4. Conclusion

This paper discusses the application of digital twin technology in practical courses, aiming at the pain points that the teaching of industrial robot application practical courses relies heavily on the number of practical training sites and equipment, and it is difficult to match the actual production. Focus on the study of online digital simulation of key equipment, production products, processing technology and typical production lines in the application scenarios such as the training site and factory workshop through the twin

technology, build the digital twin training platform, restore the typical work tasks of enterprises, and continuously and rapidly update and optimize the teaching projects for the innovation of industry technology and process. So that students in the school training can also be in line with the actual production technology of enterprises.

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