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RESEARCH AND PRACTICE ON THE CONSTRUCTION OF A VIRTUAL SIMULATION TRAINING PLATFORM FOR INTELLIGENT MANUFACTURING

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Abstract: The construction of a demonstrative virtual simulation training base for vocational education is a crucial task aimed at adapting to national strategies and digital economic development requirements, serving the cultivation of composite technical and skilled talents in the new era, and promoting the high-quality development of vocational education in the context of the rapid development of new generation information technologies represented by artificial intelligence, big data 5G, virtual reality technology, etc. In recent years, the national and local governments have continuously strengthened policy guidance, invested a large amount of financial support, and actively transformed their thinking to implement digital transformation. Major universities have explored new ways to use virtual reality new technologies to reform traditional education and teaching models, solve the "three highs and three difficulties" problems in vocational education teaching and training courses, improve teaching quality, and cultivate skilled talents that meet the needs of enterprises.In this context, we have designed and developed an intelligent manufacturing virtual simulation training platform featuring digital twin capabilities, based on the existing intelligent manufacturing training base. This platform comprises one production line with four unit islands, enabling it to simulate the entire operation process of each unit island. Through practical teaching activities involving 436 students from various majors, the platform has proven to effectively enhance students’ practical skills.
Keywords: Intelligent manufacturing; Virtual simulation; Digital twins; Training platform

1 INTRODUCTION

Following the introduction of the German Industry 4.0 and American Industrial Internet strategies, the Chinese government launched the "Made in China 2025" national development strategy in 2015. This strategy aims to foster innovative advancements in the manufacturing sector, facilitating the transition of traditional manufacturing towards intelligent manufacturing. Currently, intelligent manufacturing has emerged as the primary trend in global manufacturing development. The rapid advancements in new artificial intelligence technology, Internet technology, new generation information technology, new energy technology, material technology, and biotechnology constitute a significant aspect of this new era[1-4]. Vocational education bears the responsibility of providing talent reserves and capabilities for intelligent manufacturing. Intelligent simulation technology can effectively address the "three highs and three difficulties" in vocational education, namely the high cost, high workload, and high failure rates, as well as the difficulties in accessing resources and cost-effectiveness, thereby enhancing students' practical skills.

However, in practical teaching for intelligent manufacturing, the high investment cost of training equipment and the low utilization rate hinder the development of practical teaching. Therefore, it is particularly important to utilize virtual simulation training platforms for vocational education. The integration of virtual and real elements can effectively address the shortcomings of traditional training methods. On the one hand, it significantly reduces the investment cost of training equipment; on the other hand, by accurately simulating production data and mimicking real production environments, students are provided with practical operational experience that closely resembles reality. The use of a virtual simulation training platform not only greatly enhances students' practical skills but also effectively avoids potential risks in actual operations by creating a virtual laboratory that simulates high-risk experimental environments. The purpose of this study is to establish a virtual simulation training center for intelligent manufacturing.

2 CURRENT SITUATION AND EXISTING PROBLEMS

In the current field of education, virtual simulation training technology, as an innovative teaching method, is increasingly gaining attention for its application in professional courses. However, this technology has encountered multiple problems and challenges in its promotion and application.

2.1 Insufficient Integration of Technology and Professional Knowledge

The construction of virtual simulation training bases necessitates the integration of professional education and information technology. However, there are still instances where teachers exhibit a limited depth of technical application and rigid thinking, remaining at a superficial level of application[5, 6]. Consequently, teachers must enhance their learning and application of information technology, and integrate their professional knowledge to deeply apply it in teaching practice. This can be facilitated through teacher training, interdisciplinary collaboration, and the development of teaching resources that integrate professional knowledge and technology.

2.2 Lack of Updates and Richness in Digital Educational Resources

With the rapid development of professional knowledge and technology, digital educational resources need to be updated in a timely manner to keep pace with the times. Therefore, it is necessary to promptly update digital teaching resources, encourage teachers and professionals to participate in the development of digital educational resources, continuously optimize teaching content, and ensure that it aligns with current professional needs.

2.3 The Innovation of Digital Teaching Applications is Not High

This is reflected not only in the high level of homogenization of resources, but also in the lack of innovation in teaching methods. Therefore, it is necessary to expand teachers' learning channels and keep abreast of new affairs and methods through various avenues. Additionally, strengthen communication between universities and the outside world, especially with universities and enterprises in regions with high education standards and developed economies, to avoid working in isolation.

3 CONSTRUCTION OF VIRTUAL SIMULATION TRAINING ENVIRONMENT

Based on "Internet Plus", we aim to create a new type of classroom that integrates both online and offline, virtual and real elements. Leveraging virtual factories and VR devices, we conduct immersive and collaborative interactive teaching to cultivate students' collaborative abilities. Utilizing various terminals such as PCs, mobile phones, and tablets, we implement "cloud-based" virtual simulation training teaching, enabling learners to conduct training anytime and anywhere, thereby fostering their self-learning abilities. In the virtual integrated training area, we first conduct virtual simulation, followed by real-world training, to promote the teaching of "virtual-real integration". By implementing "online and offline, virtual and real combination" teaching, we aim to advance the "classroom revolution" of deep integration and application of virtual and real elements. Simultaneously, we utilize virtual collaborative innovation zones to carry out innovation and entrepreneurship education, enriching the content of extracurricular teaching.
The virtual simulation training base, spanning over 2000 square meters, comprises two virtual simulation professional centers, one virtual simulation experience center, a virtual simulation innovation center, a virtual production line simulation center that integrates virtual and real elements, a virtual and real electromechanical joint debugging training unit, and seven virtual simulation training rooms.

3.1 Virtual Experience Center

The virtual simulation experience center primarily relies on AR/VR/MR technologies to present the fundamental knowledge, basic skills, cultural science popularization, ideological and political courses, as well as innovative scientific research and teaching achievements in intelligent manufacturing through a variety of VR/AR/MR devices. Spanning 180 square meters, the center comprises immersive VR large-screen interactive display systems, 3D active stereoscopic glasses, virtual reality operation all-in-one devices (teacher-end), augmented reality (AR) software, AR cameras, smart interactive large screens, holographic fans, MR all-in-one devices, and other virtual simulation equipment. Within this environment, students can engage in immersive virtual simulation experiences as shown in Figure 1.

Figure 1 Virtual Experience Center

3.2 Virtual Simulation Professional Center

The indoor environment is equipped with immersive virtual simulation screens, 50 sets of virtual reality head-mounted display devices, 50 sets of graphics workstations, 10 sets of multifunctional training tables, VR helmet charging carts, and other accessories. Additionally, we have established hydraulic and pneumatic simulation training resources, simulation training resources such as Siemens PLC1200, a VR content resource management platform, multi-person collaborative adaptation software, cloud streaming software, and other related resources as shown in Figure 2.

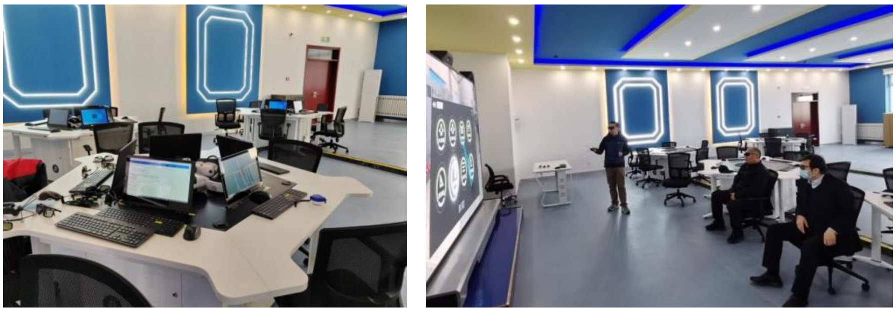

Figure 2 Virtual Simulation Professional Center

3.3 Public Virtual Center

The public virtual center has established seven training rooms, namely the mold virtual design simulation training room, computer-aided design and manufacturing virtual simulation training room, intelligent production line virtual simulation training room, and numerical control technology virtual simulation training room, among others. These rooms are designed for extensive public virtual simulation training.

3.4 A System Combining Virtual and Real in Intelligent Manufacturing Based on Digital Twins

Leveraging the resource advantages of leading enterprises in the region, and focusing on the requirements of key job positions such as intelligent production line design, installation, commissioning, operation, maintenance, etc., the school-enterprise collaboration has jointly designed, developed, and constructed an intelligent manufacturing system. The system consists of four processing units, one cleaning and marking workstation, one logistics and warehousing system, ERP, MES, and central control system[7, 8]. At the same time, based on the principles of combining reality with virtuality, using virtuality to assist reality, and integrating virtuality with reality, simulation modeling of factory equipment is carried out with reference to physical objects. A large-scale precision instrument virtual simulation system is built using digital twin technology. Students repeatedly undergo virtual training, master the operation points, and then carry out practical training on the real system, solving the problems of complex large-scale systems, invisible interiors, and high training costs, as shown in Figure 3.

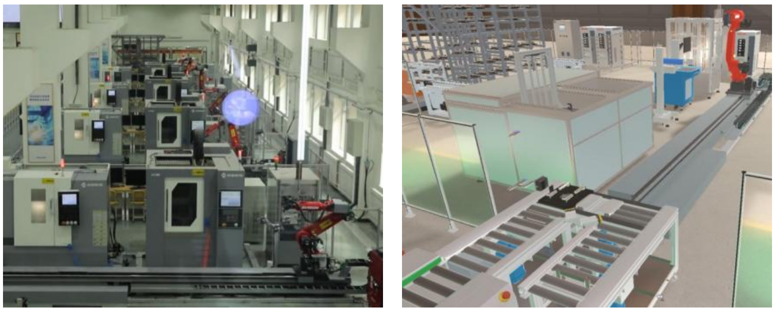

Figure 3 A system that Combines Virtual and Real Elements in Intelligent Manufacturing

4 SCHOOL ENTERPRISE JOINT CONSTRUCTION BASE

The demonstration and leading digital professional construction, jointly established by schools and enterprises, has initiated digital transformation in 70% of key technical positions in emerging industries and intelligent manufacturing cooperative enterprises, resulting in a 5% year-on-year increase in employment in the high-end manufacturing industry[9]. Through collaboration with leading companies in the industry, we have implemented "order classes". Based on real-life teaching scenarios, we have adopted the "modern apprenticeship system" and "on-site engineer" training methods, fostering a unique talent cultivation model characterized by "employment upon enrollment, work upon learning, dual-subject training, and mentor-ship training".

To bridge the gap between curriculum and practice, we invite distinguished masters (craftsmen) from enterprises to participate in teaching reform, professional construction, and other related endeavors. We integrate enterprise production standards into talent cultivation practices and embed the spirit of craftsmanship into students' growth and development. This major has hired over 30 part-time teachers who are currently employed by enterprises. In recent years, teachers have participated in practical training in enterprises and have grown into technical experts at the provincial and municipal levels[10]. Consequently, the employment competitiveness and development potential of both teaching masters and students have significantly improved.

Based on a thorough analysis of the professional knowledge, skills, and qualities required for each position, both the school and enterprise establish professional talent training objectives. Incorporating the enterprise's typical work tasks and professional ability requirements, they collaboratively devise a practical and feasible professional talent training plan that aligns with job requirements. Together, they develop course content tailored to professional job groups and refine a professional curriculum system based on typical work processes. They also jointly establish curriculum standards, job skill standards, and quality monitoring standards. Both parties will collaboratively integrate school and enterprise resources to create a multifunctional teaching and training base that fosters the comprehensive development of highly skilled talents.

5 THE CONSTRUCTION EFFECTIVENESS OF VIRTUAL SIMULATION CENTER

Intelligent manufacturing stands as the core driving force behind current industrial development, with virtual simulation technology emerging as a pivotal tool for nurturing talents in this field. To align with this trend, we have expedited the construction of the intelligent manufacturing virtual simulation training room. This training base not only facilitates virtual simulation of current intelligent manufacturing training, but also strives to leverage its unique strengths in multiple dimensions.

Through virtual simulation technology, we can effectively simulate real intelligent manufacturing environments, enabling students to engage in practical training operations without any risks. This simulated environment is not only safe, but also allows students to gain a deeper understanding of the manufacturing process and operational details of equipment. Additionally, virtual simulation technology can provide students with more practical operation opportunities, thereby helping them better master skills and improve their skill levels.

The establishment of virtual simulation training rooms has significantly reduced the cost of practical training. In traditional on-site training, high costs are often incurred due to equipment wear and material waste. Through virtual simulation technology, we can conduct practical training in a virtual environment, thereby avoiding these losses and wastes and effectively reducing costs.

Virtual simulation training, as an educational technology tool, provides learners with highly customized learning experiences. In a simulated environment, students can independently choose suitable training modules for operational exercises based on their own learning pace and preferences. This personalized learning method not only helps to stimulate learners' enthusiasm, but also promotes their deeper understanding and mastery of the required skills, thereby enhancing learning effectiveness.

The application of virtual simulation technology in the manufacturing industry can significantly enhance production efficiency and reduce operating costs, thereby strengthening the market competitiveness of enterprises. Leveraging this technology, manufacturers can perform high-precision simulations in product design and production process optimization, aiming to maximize efficiency and optimize costs.

6 CONCLUSION

Through the construction of a virtual simulation platform for intelligent manufacturing, the existing automation hardware equipment and production lines have undergone digital transformation. At the same time, digital course resources related to the intelligent manufacturing professional group have been developed, significantly improving the utilization of training hardware resources, enhancing the effectiveness of training teaching, while reducing education costs and saving maintenance and equipment update costs. Making the learning experience closer to real work scenarios in teaching not only helps students better adapt to future work environments, but also enriches practical experience, improves innovation ability, and achieves deep integration of industry, academia, research, and application.

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COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

[1] Zheng P, Wang HH, Sang ZQ, et al. Smart manufacturing systems for Industry 4.0: conceptual framework, scenarios, and future perspectives. Frontiers of Mechanical Engineering, 2018, 13, 137-150. DOI: https://doi.org/10.1007/s11465-018-0499-5.

[2] Tao F, Qi QL, Liu A, et al. Data-driven smart manufacturing. J Manuf Syst, 2018. 48, Part C, 157-169. DOI: https://doi.org/10.1016/j.jmsy.2018.01.006.

[3] Zhong RY, Xu X, Klotz E, et al. intelligent manufacturing in the context of Industry 4.0: a review. Engineering, 2017, 3(5): 616-630. DOI: https://doi.org/10.1016/J.ENG.2017.05.015.

[4] Yadav A, Jayswal SC. Modelling of flexible manufacturing system: a review. International Journal of Production Research, 2017, 56(7): 2464-2487. DOI: https://doi.org/10.1080/00207543.2017.1387302.

[5] Wang W, Wang X, Wu W, et al. Research on virtual simulation training base in higher vocational colleges. China Journal of Multimedia & Network Teaching, 2024, 07.

[6] Ye,WY. Research and Practice on the Construction of Virtual Simulation Training Center Based on Intelligent

Manufacturing. Equipment Manufacturing Technology, 2024, 08.
[7] Liu,YG,Yao, LQ, Zhu, H. Practice of Digital Twin Virtual Simulation in Intelligent Manufacturing Production Line Technology Course. Science & Technology Information, 2023, 21(04). DOI: 10.16661/j.cnki.1672-3791.2207-5042-5588.
[8] Liu, M, Zhang, LD, Zheng J, et al. Design and Implementation of Digital Twin for Smart Factory. Automation Technology and Applications, 2024, 5.
[9] Xu, XL, Liu, S, Li HY, et al. Research and Practice on the Construction of Virtual Simulation Training Base for Smart Agricultural Equipment. Smart Agriculture Guide, 2024, 16.
[10] Luo, BF, Tong, ZL, Long YK, et al. Exploration of Intelligent Manufacturing Virtual Simulation Platform Construction in the Era of New Engineering Science. Machinery Management Development, 2024.