Research on a New Paradigm of Virtual Simulation Training Teaching in Vocational Education Driven by Generative AI

Dan Liu*, Yuan Xia, Wei Zheng
School of Intelligent Manufacturing, Chongqing Industry and Trade Polytechnic, Chongqing, China
**Corresponding author*

Abstract: In the dual context of digital transformation in vocational education and the deep application of artificial intelligence technology, traditional virtual simulation training teaching generally faces practical challenges such as lagging content updates, limited resource adaptability, and inefficient evaluation feedback. This paper takes equipment manufacturing vocational education as the research object, explores the integration path of generative AI and virtual simulation training, builds a new "AI+virtual simulation" training teaching system, and designs an implementation plan covering intelligent platforms, blended teaching modes, and diversified evaluation feedback. The research shows that generative AI can achieve on-demand creation of training scenarios, personalized customization of learning paths, full-process tracking of teaching processes, and closed-loop optimization of teaching quality, effectively solving the long-standing "three highs and three difficulties" issues in vocational training, and enhancing the fit between practical teaching quality and talent cultivation.

Keywords: Generative AI; Virtual Simulation; Vocational Education; Practical Training Teaching

1. Introduction

Vocational education, as the main front for cultivating technical and skilled talents, is directly related to industrial upgrading and high-quality economic development. With the introduction of policy documents such as the "National Vocational Education Reform Implementation Plan" and the "Outline of the Plan for Building a Strong Education Country (2024-2035)", the state has clearly required the promotion of deep integration of information technology with education and teaching, utilizing artificial intelligence technology to drive the transformation of teaching modes from "standardization" to "personalization", and building a new ecosystem of smart education [1,2]. Currently, virtual simulation technology has been widely applied in practical training teaching in higher vocational education, effectively solving the "three highs and three difficulties" issues of high cost, high loss, high risk, difficult implementation, difficult observation, and difficult reproduction, with a coverage rate of over 60% [3].

Generative AI possesses capabilities such as automatic content creation, intelligent data analysis, and real-time interactive response, providing key technical support for the innovation of virtual simulation training teaching mode. Therefore, deeply integrating generative AI into practical teaching to build a dynamic, intelligent, personalized, and interactive new training system has become an important direction for the digital transformation of vocational education [4].

2. Current Situation and Problems of Practical Training Teaching in Vocational Education

In the context of digital transformation, despite significant progress in practical training teaching in vocational education, there are still many deep-rooted contradictions and practical challenges in meeting the needs of high-quality industrial development and the application of intelligent technology, mainly manifested in three dimensions: teaching content, resource development, and evaluation mechanisms.

2.1 Inadequate Quality and Industry Adaptability of Teaching Content

The core objective of practical training in vocational education is to cultivate practical abilities that align with industry positions. However, there is a notable disconnect between the current practical training content in most institutions and the cutting-edge technologies, new processes, and new norms in the industry. The equipment manufacturing industry is rapidly moving towards intelligent, digital, and flexible production, with technologies such as industrial robots, numerical control systems, smart production lines, and digital twins being widely applied [5]. Meanwhile, traditional practical training materials and virtual simulation projects still emphasize basic operations and fixed processes, failing to cover cutting-edge content such as intelligent manufacturing units, digital processes, online quality inspection, and intelligent equipment operation and maintenance. Furthermore, the design of practical training content often follows disciplinary logic rather than the logic of actual work processes, leading to fragmented skill points and task points that are disconnected from real production scenarios. This mismatch between the skills students acquire and the actual job requirements of enterprises results in a "disconnection between learning and application" phenomenon, making it difficult for the supply side of talent cultivation to precisely align with the demand side of the industry [6].

2.2 The Development and Updating of Practical Training Resources Lag Behind

The development of virtual simulation training resources is characterized by long cycles, high costs, and high technical thresholds. Traditional development models rely on professional technical teams for modeling, programming, and debugging. Developing a complete virtual simulation project for equipment manufacturing can take several months or even longer, and the investment cost can reach hundreds of thousands of yuan. In the context of rapid technological iteration, existing virtual resources are difficult to keep up with the pace of enterprise equipment updates, process upgrades, and standard adjustments, resulting in a disconnect between training scenarios, operating procedures, and technical parameters and actual production. In addition, training resources are mostly independently developed or purchased by individual institutions, lacking mechanisms for cross-school sharing or industry-university-research cooperation. Resource homogenization is severe, and the reuse rate is low, making it difficult to form a large-scale, systematic, and dynamically updated training resource library [7]. Some institutions, limited by funding and technical capabilities, can only use simplified and low-precision simulation resources, which lack realism and immersion in training and cannot achieve high-quality skill training effects [8].

2.3 Imperfect Teaching Evaluation And Feedback Mechanism

Traditional virtual simulation training teaching evaluation primarily focuses on outcome-based assessments, emphasizing static indicators such as operational completion and step accuracy, while neglecting process-based evaluations of students' comprehensive professional abilities, including problem-solving, fault diagnosis, team collaboration, and innovative thinking. The evaluation methods typically involve manual scoring by teachers and fixed scoring by systems, which are highly subjective and have a single dimension, making it difficult to comprehensively reflect students' practical training performance [9]. At the same time, the feedback mechanism exhibits significant lag, and process errors, skill gaps, and cognitive misunderstandings that arise during simulated operations cannot be resolved through real-time, precise, and personalized guidance. Students can only receive general evaluations after the training ends, which hinders timely correction of errors and consolidation of skills. Furthermore, the lack of systematic data collection and in-depth analysis prevents teachers from accurately identifying learning challenges and individual differences across the entire class, making it difficult to achieve solid foundations for teaching improvement, "teaching students according to their aptitude," and closed-loop improvement in teaching quality.

3. Construction of a New Paradigm for Virtual Simulation Training Teaching Driven by Generative AI

To address issues such as outdated traditional training content, insufficient adaptability, and inefficient feedback [10], this paper proposes a new paradigm of virtual simulation training teaching, with generative AI as the core driving force. It constructs a new integrated teaching system of "AI + virtual simulation", with the core concepts of "dynamic generation, intelligent adaptability, and closed-loop improvement". It systematically reconstructs the training system from three aspects: content generation, teaching organization, and evaluation feedback, as shown in Figure 1.

At the content generation level, a training scenario generation mechanism is established based on large language models and diffusion models. This mechanism utilizes typical data from the field of intelligent manufacturing for training, automatically generating diversified training tasks, equipment statuses, and operating conditions, achieving personalized supply tailored to individual needs. At the teaching organization level, an intelligent learning guidance model is established relying on ability portraits and knowledge graphs. By collecting student behavior data, it provides adaptive task recommendations and layered guidance, helping students plan personalized learning paths. At the evaluation and feedback level, a multi-dimensional ability evaluation model is constructed by integrating outcome indicators and process data. Through generative AI, it automatically sorts out problem localization and typical cases, promoting deep learning and metacognitive development. These three aspects work together to ultimately form a closed loop of continuous improvement in teaching quality, truly addressing training pain points and achieving precise matching between industry and education.

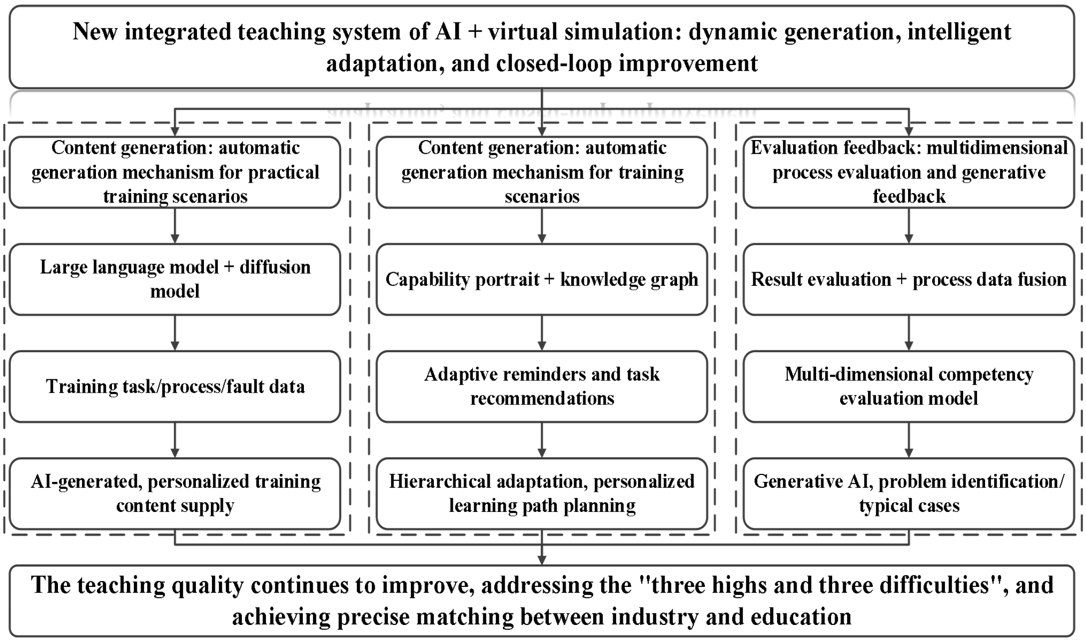

Figure 1. The New Integrated Teaching System of "AI+ Virtual Simulation"

4. Implementation Path and Practical Application

4.1 Build a Generative AI Intelligent Virtual Simulation Training Platform

With schools as the main body and in collaboration with enterprises to build an intelligent training platform, the underlying layer relies on cloud computing and computing power support, the middle layer deploys generative large models and a digital twin engine, and the top layer hosts training and teaching application modules, as shown in Figure 2. The core functions of the platform include: intelligent scheduling of training tasks with automatic generation of 3D scenes and equipment models, natural language interaction guidance, real-time capture of operational behaviors, intelligent diagnosis of skill shortcomings, automatic creation of evaluation reports, and visual analysis of teaching data. The platform also interfaces with real production system data from enterprises, importing typical workpieces, process parameters, quality standards, and fault databases to ensure that the simulation scenarios highly replicate industrial environments, achieving a "seamless connection" between on-campus simulation training and enterprise job operations.

Taking the practical training of "Industrial Robot Assembly Workstation Debugging" in equipment manufacturing majors as an example, teachers can set learning objectives such as "assembly takt time optimization", "trajectory planning and collision detection", and "fault diagnosis and troubleshooting". The AI system automatically creates three sets of virtual workstation scenarios with different levels of difficulty and randomly generates typical faults such as "clamping jaw jamming", "sensor false triggering", and "program logic error". Students need to complete fault diagnosis and system debugging within a limited time. The content versions generated for each practical training session are different, which can effectively prevent "memorizing answers" training and enhance the openness and challenge of practical training.

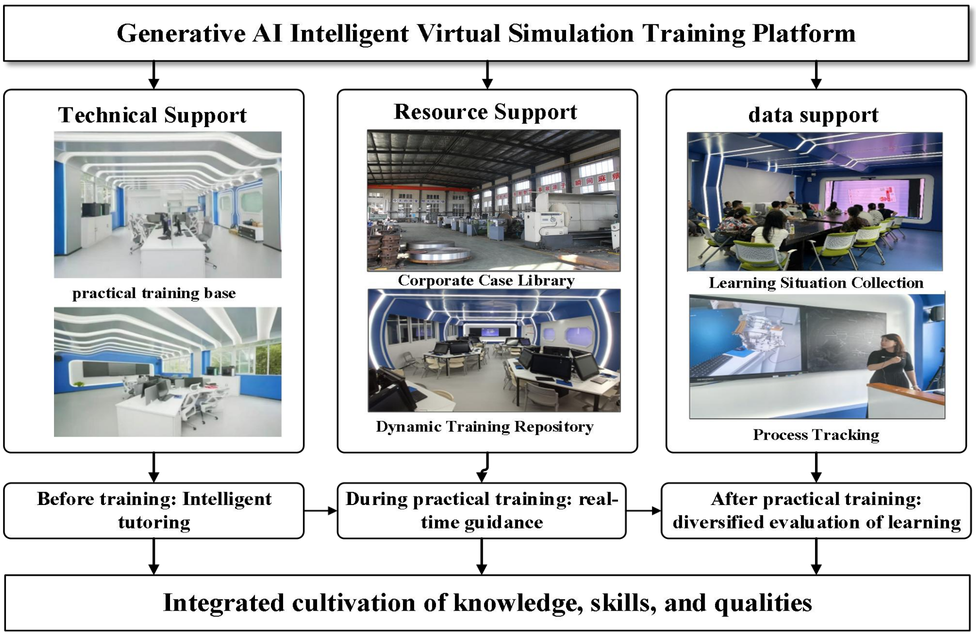

Figure 2. Overall Framework of Generative AI Virtual Simulation Training Platform

4.2 Reconstructing the "AI + Virtual and Real Integration" Hybrid Training Teaching Model

This article breaks the traditional model of 'theory first, then hands-on training, with simulation training conducted separately' and builds a hybrid training mode of 'online AI-guided learning and offline practical reinforcement,' as shown in Figure 3. Before training, the AI system generates preview materials, basic knowledge points, and entry-level simulation tasks based on students' pre-test results. During training, students enter a highly immersive virtual environment to complete the full process, including assembly, debugging, testing, and troubleshooting. The system provides real-time error correction, step-by-step guidance, and records key operation data. After training, targeted reinforcement tasks are pushed for weak skills, combined with on-campus training stations and company workshops for practical validation, forming a closed-loop approach of 'building a foundation in virtual practice, strengthening skills in hands-on training, and improving competence on-site.' This model balances safety, cost-efficiency, and practical effectiveness, significantly boosting the efficiency of skill training.

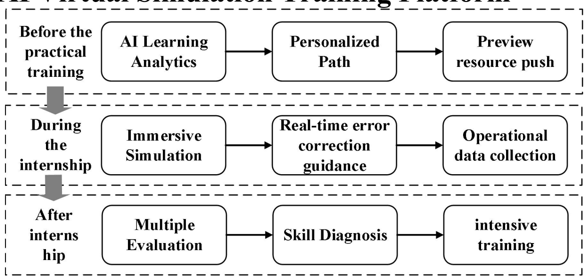

Figure 3. "AI+Virtual and Real Integration" Hybrid Training Teaching Flowchart

4.3 Establish a Mechanism for Multiple Intelligence Assessment Feedback and Closed-Loop Improvement

Establish a four-in-one diversified evaluation system encompassing "process evaluation, result evaluation, ability evaluation, and literacy evaluation". The AI system conducts real-time quantitative scoring based on operational standardization, step completeness, efficiency, and quality. Teachers conduct subjective assessments of fault analysis thinking, process selection rationality, and compliance with safety standards. Enterprise experts are introduced to conduct external evaluations of comprehensive vocational abilities based on job standards. Meanwhile, students conduct mutual evaluations and self-assessments through the system. After the evaluation, a personalized learning diagnosis report is automatically generated, clearly indicating strengths and areas for improvement, and pushing targeted improvement tasks. Finally, evaluation data at the class, major, and course levels are summarized to form teaching improvement suggestions, promoting continuous optimization of course content, practical training projects, and teaching methods, achieving a quality closed loop of "evaluation-feedback-improvement-enhancement".

5. Conclusion

Generative AI brings innovative changes to virtual simulation training teaching in vocational education, effectively addressing challenges such as lagging traditional training content, rigid resources, inefficient feedback, and singular evaluation. It promotes the transformation of training teaching from "standardized, passive, result-oriented" to "personalized, active, process-oriented, quality closed-loop", which holds significant theoretical value and practical significance for enhancing the quality of technical skill talent cultivation. Focusing on key industries such as equipment manufacturing, the new paradigm of virtual simulation training driven by generative AI ensures that training scenarios align with industry needs and skill training matches job requirements, thereby assisting vocational education in better serving the high-end, intelligent, and green development of the manufacturing industry.

To ensure the continuous implementation of the new paradigm, support needs to be strengthened in four directions in the future: First, technical implementation guarantee, increasing investment in computing power, algorithms, and data, improving platform functions, and enhancing the realism of scenarios and the smoothness of interaction; second, teacher capability building, conducting training on AI technology application for teachers, virtual simulation teaching design, and industry-education integration course development, and building a composite teacher team; third, school-enterprise collaboration guarantee, deepening industry-education integration and school-enterprise cooperation, jointly building a dynamic practical training resource library, jointly developing job-adaptive practical training projects, and jointly formulating evaluation standards; fourth, standardization and security guarantee, establishing AI practical teaching application standards, data security standards, and ethical guidelines to ensure the compliance, safety, and controllability of technology application.

Acknowledgments

This paper was supported by the Chongqing Higher Vocational and Technical Education Research Association Research Project (Generative AI-Driven New Paradigm for Virtual Simulation Training in Vocational Education, GZY2025036) and 2026 annual mechanical industry vocational education "industry-university-teaching collaborative innovation" project (Research on the Collaborative Digital and Intelligent Upgrade Path of Higher Vocational Equipment Manufacturing Majors under the New Engineering Background).

References

[1] Liu J, Zhao Z L, Liu X. Feasibility Analysis of Training System Reconstruction Based on Virtual Simulation Technology-A Case Study of Intelligent Welding Technology Major. Welding Technology, 2022, 51 (11):109-112.

[2] Xinhua News Agency, Portal Website of Ministry of Education of China. Outline for Building a Strong Education Country (2024-2035). Qinghai Education, 2025(1):17-21.

[3] Yang J F, Shen M T, Li S J. Artificial Intelligence Driven Digital Transformation of Vocational Education: Action Framework and Practical Strategy [J]. Vocational Education Forum, 2026, 42 (1):23-29.

[4] Yan L R, Chu J W, Li Z Y, et al. Research on the Path of Integrative Generative Artificial Intelligence into Professional Courses of Information Resource Management. Journal of Library Science, 2025, 44(1):128-138,157.

[5] Zheng S Z, Suo Y J. Research on the Construction of Virtual Simulation Training Bases in Vocational Education from the Perspective of Industry-Education Integration-A Case Study of Mechatronics Technology Major. Vocational Education, 2025, 24 (27):62-66.

[6] Liu H, Gao Q, Li C, et al. Research on the Construction of Innovative Teaching Mode of Virtual Simulation Training-Taking Intelligent Manufacturing Major Group as an Example. Papermaking Equipment & Materials, 2024, 53 (11):203-205.

[7] Yang Z X. Design and Application of Smart Open Training Platform for Emerging Engineering Based on Cloud Computing Technology//Hubei Society of Mechanical and Electrical Engineering. Proceedings of 2025 Mechanical and Electrical Innovation & Industry-Education Integration Symposium. Changjiang Publishing Media & Hubei Science and Technology Press, 2025:462-467.
[8] Yuan J, Zhai X S, Wu F, et al. Construction of University Artificial Intelligence Major (AI+X Track) Based on Virtual Teaching Research Office: A Case Study of Zhejiang University. Modern Educational Technology, 2024(5):123-133.
[9] Xu Z, Xiao F. Research and Practice on School-Enterprise Co-development of Virtual Training Resources Based on AIGC Technology. Chemical Management, 2025 (26):36-39.
[10]Hu C L, Luo L M, Chen F Y. Construction of Smart Industry-Education Integrated Training Base to Digitally Empower Vocational Education Teaching Reform-A Case Study of Hubei Industrial Polytechnic. Journal of Hubei Industrial Polytechnic, 2024, 37 (1):1-5.