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Research on the Construction of a Three-Platform Three-Stage Practical Teaching System in Higher Vocational Education under the Background of Intelligent Manufacturing

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Abstract

With the rapid development of intelligent manufacturing technology, practical teaching in higher vocational electromechanical majors faces challenges including disconnection between teaching content and industrial technology, insufficient training conditions for real production needs, and inadequate cultivation of students innovative ability. Taking the Automation Production Line Technology Comprehensive Application course as an example, this paper proposes and constructs a practical teaching system integrating three platforms (training base, innovation platform, and production enterprise) and three stages (simulation training, practical operation reinforcement, and internship improvement). The study elaborates the construction logic, operation mechanism, and guarantee measures of the three-platform three-stage practical teaching system, and analyzes its implementation effect in cultivating students ability to transform automation production lines, providing a reference framework for practical teaching reform in intelligent manufacturing related majors.

Keywords

Intelligent Manufacturing; Practical Teaching System; Three Platforms and Three Stages; Automation Production Line; Higher Vocational Education

1. Introduction

Intelligent manufacturing represents the core direction of the Made in China 2025 strategy, and the technical transformation and upgrading of automation production lines constitute a critical component of the manufacturing industry transformation and upgrading [1]. As the pillar industry of the Wenzhou region, the electrical industry holds an important position in the national low-voltage electrical apparatus sector. With the increasingly strong demand for machine replacement, the regional equipment manufacturing industry has witnessed a sustained growth in demand for high-quality technical and skilled talents capable of mastering automation production line technical transformation capabilities [2].

As the primary arena for cultivating technical and skilled talents, higher vocational education bears the important mission of delivering qualified personnel for regional industries. However, traditional practical teaching models demonstrate obvious inadequacies in addressing the development needs of the intelligent manufacturing industry. First, practical teaching content updates lag behind the speed of industrial technology iteration, with a significant gap between virtual simulation training and real production environments. Second, practical teaching resources are dispersed, with insufficient effective linkage among on-campus training bases, technology innovation platforms, and off-campus production enterprises. Third, practical teaching segments provide insufficiently systematic cultivation of student innovation capabilities, with limited opportunities for students to participate in real technical transformation projects [3].

In response to the above issues, this study takes the Mechatronics Technology major at Wenzhou Polytechnic as the core carrier, with the Automation Production Line Technology Comprehensive Application course as the focal point, and constructs a three-platform three-stage practical teaching system. This system relies on three carriers: training bases, innovation platforms, and production enterprises, and implements progressive education through three stages: simulation training, practical operation reinforcement, and internship improvement, with the aim of providing operable reference solutions for practical teaching reform in intelligent manufacturing related majors.

2. Practical Demands for Higher Vocational Practical Teaching Reform under the Background of Intelligent Manufacturing

2.1. New Requirements Posed by Industrial Development for Talent Cultivation

Under the background of intelligent manufacturing, automation production lines exhibit development trends toward intelligence, networking, and flexibility, posing higher requirements for practitioners professional competencies. Through investigation of enterprises in the Wenzhou electrical industry, it was found that enterprise expectations for higher vocational graduates capabilities concentrate on three levels. At the basic level, graduates are expected to proficiently master core technical skills including PLC programming, industrial robot operation, and machine vision debugging. At the comprehensive level, they should be able to complete overall automation production line joint debugging, fault diagnosis, and operation maintenance. At the innovation level, they should possess the capability to participate in the design, implementation, and optimization of production line technical transformation projects [4].

Notably, enterprises generally report that current graduates have shortcomings in comprehensive application capabilities and innovative awareness. While most students can complete single-skill operations, they often lack systematic problem analysis and creative problem-solving abilities when facing comprehensive technical transformation tasks requiring multidisciplinary knowledge intersection. This reality indicates that higher vocational practical teaching needs to transition from single-skill training to comprehensive application capability cultivation, and from imitation operations to innovative practice [5].

2.2. Main Problems in the Current Practical Teaching System

Through reviewing the current state of practical teaching in electromechanical majors at multiple domestic higher vocational colleges, several common problems have been identified. First, the fragmentation of practical teaching resource construction. On-campus training bases, off-campus internship enterprises, and teacher research platforms operate independently without unified planning and integration, making it difficult to form educational synergy[6]. Second, the homogenization of practical teaching content. Most institutions still employ teaching models dominated by traditional verification experiments and comprehensive training, with a low proportion of design-oriented and innovative practical projects that are not closely aligned with real enterprise technical needs. Third, the segmentation of practical teaching organization. There is insufficient organic connection among cognitive internships, course practical training, and post internships, and students practical capability improvement at different stages lacks coherence and systematicity[7].

The root of these problems lies in the lack of holistic design and process connectivity in the practical teaching system, with disconnects between on-campus teaching and off-campus practice, basic training and comprehensive application, and skill mastery and innovation cultivation. Therefore, it is necessary to construct a new practical teaching system that can effectively integrate multiple carriers and coherently connect multiple stages.

3. Construction Logic of the Three-Platform Three-Stage Practical Teaching System

3.1. Construction Philosophy

The three-platform three-stage practical teaching system follows the following core philosophies. First, the progressive capability philosophy. According to cognitive laws and capability formation logic, the practical teaching process is designed as a progressive path from simple to complex, from single to comprehensive, and from imitation to innovation, ensuring that students receive appropriate capability training at each stage [8]. Second, the carrier synergy philosophy. Fully leveraging the resource advantages of on-campus training bases, technology innovation platforms, and off-campus production enterprises, enabling the three carriers to assume different functions and play their respective strengths in talent cultivation, forming a complementary and synergistic educational pattern. Third, the industry-education integration philosophy. Embedding real enterprise production tasks and technical needs throughout the entire practical teaching process, enabling students to learn and grow in authentic professional contexts, and shortening the adaptation period from campus to workplace[9].

3.2. System Architecture

The three platforms assume different educational functions respectively. The training base serves as the main venue for basic capability cultivation, equipped with automation production line training platforms, industrial robot workstations, and machine vision experimental devices, primarily conducting virtual simulation practical training and basic skill training, addressing the problem of knowing how to do. The innovation platform functions as an incubator for comprehensive capability enhancement, relying on school-enterprise jointly built technical service teams to conduct teaching around real enterprise technical transformation projects, addressing the problem of doing well. The production enterprise serves as the battlefield for position capability formation, where students complete post internships in real work environments and achieve the transition from student to professional by solving actual production problems [6].

The three stages correspond to practical teaching at different levels respectively. The simulation training stage focuses on virtual simulation practical training, where students use virtual simulation software to become familiar with the structural principles, process flows, and operation methods of automation production lines, establishing preliminary cognition of position work. The practical operation reinforcement stage focuses on physical equipment operation, where students complete the installation, debugging, programming, and joint debugging of each functional unit at the training base, forming proficient operational skills through repeated training. The internship improvement stage focuses on enterprise production practice, where students participate in production line operation maintenance and technical transformation under the guidance of enterprise mentors, exercising comprehensive application capabilities and innovative thinking through real projects [7].

A matrix-style correspondence is formed between the three platforms and the three stages: simulation training is mainly completed at the training base; practical operation reinforcement is conducted synchronously at the training base and innovation platform; internship improvement primarily takes place at the production enterprise with the innovation platform playing a supplementary role. This design enables precise matching between platform resources and stage needs, avoiding resource waste and redundant construction.

4. Implementation Paths of the Three-Platform Three-Stage Practical Teaching System

4.1. Implementation of the Simulation Training Stage

The simulation training stage is mainly implemented during the first to third semesters, with the core goal of helping students establish professional cognition and master basic operational principles. This stage relies on the virtual simulation system at the on-campus training base for teaching, where enterprise mentors are responsible for providing authentic enterprise case materials, including real enterprise production task documents, production process files, and equipment operation manuals [8].

Taking the Automation Production Line Technology Comprehensive Application course as an example, the virtual simulation segment covers core modules including material detection and sorting control for the supply unit, robotic arm handling and positioning control for the machining unit, precision assembly and visual inspection for the assembly unit, category recognition and diversion control for the sorting unit, and variable frequency speed regulation and positioning control for the conveying unit. Students first complete independent programming and debugging of each unit in the virtual environment, then proceed to whole-line joint debugging to simulate the operation process of a real production line. The advantage of virtual simulation training lies in its repeatability and error tolerance, effectively reducing training costs and equipment wear risks.

4.2. Implementation of the Practical Operation Reinforcement Stage

The practical operation reinforcement stage is mainly implemented during the fourth to fifth semesters, with the core goal of enabling students to verify and deepen the knowledge learned during the simulation stage on real equipment, forming proficient operational skills. This stage simultaneously relies on physical equipment at the training base and technical transformation projects at the innovation platform for teaching [9].

At the training base, students complete tasks of assembly, programming, debugging, and optimization of physical automation production lines in groups. Enterprise mentors introduce new enterprise standards, including enterprise operational norms, process requirements, and task evaluation standards, and provide guidance and evaluation for students operational processes. School mentors are responsible for supplementary theoretical explanations and analysis of technical difficulties. At the innovation platform, students begin to encounter real technical transformation needs from enterprises, such as the relay automatic assembly line visual inspection system optimization project commissioned by an electrical enterprise. Under the joint guidance of both mentors, students participate in the entire process from requirements analysis, scheme design, system debugging to effect evaluation, applying classroom learning to practical problem solving.

4.3. Implementation of the Internship Improvement Stage

The internship improvement stage is mainly implemented during the sixth semester, with the core goal of enabling students to complete comprehensive vocational capability training and professional quality development in real work scenarios. This stage primarily takes the form of students undertaking post internships at cooperative enterprises, where students assume position responsibilities under the one-on-one guidance of enterprise mentors and participate in daily operation maintenance and technical transformation projects [10].

During the internship, students are required to complete an internship task list jointly developed by both school and enterprise, including routine work tasks such as equipment inspection, troubleshooting, and program backup, as well as project-based work tasks such as participating in the implementation of certain technical transformation schemes. Enterprise mentors focus on guidance regarding workplace norms, position requirements, and job tasks, while school mentors track student internship situations through regular visits and online communication, coordinating solutions to problems encountered during the internship. After the internship, students submit internship reports and technical transformation summaries, which are jointly assessed by both school and enterprise.

5. Implementation Results and Guarantee Mechanism

5.1. Implementation Results

After three academic years of operation, the three-platform three-stage practical teaching system has achieved positive results. In terms of course construction, practical teaching resource packages have been developed for three core courses: Automation Production Line Technology Comprehensive Application, Industrial Robot Programming and Application, and Machine Vision Technology and Application, including virtual simulation project libraries, enterprise case libraries, and practical training task documents. The systematicness and applicability of teaching resources have been significantly enhanced.

In terms of student capability cultivation, students participating in this practical teaching system showed an increase in awards at provincial-level and above vocational skill competitions by nearly double compared to pre-implementation levels, with vocational skill certificate acquisition rates exceeding 90 percent. More importantly, through training at the innovation platform and enterprise internships, the proportion of students selecting real enterprise technical transformation topics for their graduation designs increased significantly, and the application value and innovativeness of graduation designs were enhanced.

In terms of school-enterprise cooperation deepening, the implementation of this system has promoted in-depth cooperation between the school and electrical industry enterprises in the region, with five new stable off-campus internship bases established, and continuous expansion of cooperation between school and enterprise in course development, textbook compilation, and standard formulation.

5.2. Guarantee Mechanism

To ensure the effective operation of the three-platform three-stage practical teaching system, the following guarantee mechanisms have been established. Organizational guarantee: A practical teaching work committee jointly participated by both school and enterprise parties has been established, responsible for coordinating three-platform resources and connecting three-stage teaching, holding regular joint meetings to study and solve operational problems [10].

Faculty guarantee: A school teacher enterprise practice system has been established, requiring professional teachers to spend no less than one month per academic year at enterprises participating in technical transformation projects or production practice, maintaining timely understanding of enterprise technology developments. Simultaneously, an enterprise mentor teaching capability training system has been established, improving enterprise mentors teaching levels through teaching method lectures, teaching observation, and collective lesson preparation.

Institutional guarantee: Practical teaching quality standards have been formulated, clarifying teaching objectives, content requirements, and assessment standards for the three stages. A student internship rights protection mechanism has been established, strictly implementing Ministry of Education regulations on vocational school student internship management, ensuring that internship positions match majors, internship times are reasonable, and internship compensation meets standards.

Conditional guarantee: Continuous investment in training base construction, updating virtual simulation software and physical training equipment. Relying on the industry-education alliance to expand the service scope and project sources of the innovation platform. Deepening cooperation with leading enterprises through order classes and modern apprenticeship forms, ensuring the quantity and quality of internship positions.

6. Conclusion

Facing the development needs of the intelligent manufacturing industry, reconstructing the practical teaching system for higher vocational electromechanical majors is an inevitable choice for improving talent cultivation quality. The three-platform three-stage practical teaching system proposed in this paper integrates three carriers: training bases, innovation platforms, and production enterprises, and connects three stages: simulation training, practical operation reinforcement, and internship improvement, constructing a new practical teaching paradigm featuring progressive capabilities, carrier synergy, and industry-education integration. This system has achieved positive results in the practice of the Mechatronics Technology major at Wenzhou Polytechnic, providing referable experience for similar institutions practical teaching reform.

It should be noted that the implementation of the three-platform three-stage practical teaching system is a systematic project, requiring continuous efforts from the school in organizational leadership, funding investment, faculty construction, and school-enterprise cooperation. Future efforts will further optimize the connection mechanisms among the three platforms, explore the application of information technology in practical teaching management, establish more scientific and comprehensive practical teaching quality evaluation systems, and promote continuous deepening of practical teaching reform.

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