Research on the Collaborative Upgrading Path of Digitalization and Intelligence for Equipment Manufacturing Majors in Higher Vocational Education under the Background of New Engineering

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Abstract: The accelerating digital-intelligent transformation of global manufacturing highlights new-engineering-driven reforms for higher vocational engineering education. Chinese higher-vocational equipment-manufacturing majors face "technical-island" defects caused by disconnected digital and intelligent construction, with talent-training and curriculum iteration lagging behind smart-factory industrial demands. Based on new-engineering concepts of cross-integration and dynamic adaptation, this paper establishes a three-dimensional collaborative upgrading framework including a quantitative major-adjustment evaluation model, a school-enterprise virtual-simulation multi-scenario platform, and a dual-platform double-helix teacher-growth mechanism. This integrated system shortens the supply-demand gap between vocational talent cultivation and industrial innovation, eases structural conflicts for compound digital-craftsman training, and provides a replicable reference for the digital-intelligent upgrading of related higher-vocational major groups.

Keywords: Higher Vocational Equipment Manufacturing; Ofessional Upgrading; Industry-Education Collaboration; Digitalization; Telligentization

1. Introduction

The new round of scientific and technological revolution and industrial reform drive the overall transformation of China's equipment manufacturing industry to the digital intelligent mode. The state has successively issued the "14th five year plan for the development of digital economy" [1] and the "plan for the adjustment and optimization of the setting of disciplines and specialties in general higher education" [2] and other policy documents, clearly proposing to implement the all factor transformation and upgrading of engineering majors with digital and intelligent technologies, so as to promote the in-depth adaptation of vocational education to the strategy of manufacturing power and digital China. Digital twin, industrial Internet, intelligent sensing, artificial intelligence and other technologies have fully penetrated the whole production chain of design, processing, operation and maintenance, and the flexible intelligent production line has gradually become the mainstream production carrier in the industry. The innovation of the industrial model simultaneously reshapes the talent demand structure of enterprises. The market no longer only needs front-line technicians who master the operation of basic equipment, but also needs compound digital craftsmen with comprehensive abilities such as digital process design, industrial data processing, intelligent production line commissioning and operation and maintenance. However, the industry survey data reflect that there are obvious shortcomings in the construction of equipment manufacturing major in Higher Vocational Colleges: 63% of the relevant majors have not included the core digital content such as industrial software and intelligent control system into the talent training program; 75% of school enterprise cooperation only stayed in the shallow cooperation of equipment donation and short-term visit and internship, and did not touch the systematic reconstruction of curriculum system, teaching evaluation and training standards; Industrial robots, MES operation and maintenance and other job skills need to be updated at an average annual rate of 35%, while the overall curriculum update cycle of higher vocational colleges is as long as 4-5 years, and there is a significant gap between talent supply and real industrial demand. The new engineering reform emphasizes interdisciplinary, dynamic iteration and deep integration of production and education, and requires the equipment manufacturing major in Higher Vocational Colleges to break the traditional idea of digital and intelligent segmentation construction [3]. Based on the above practical contradictions and policy guidance, this paper takes the idea of cross-border integration of new engineering as the theoretical support, explores the implementation path of digital and intelligent integration collaborative upgrading of equipment manufacturing specialty, and provides a theoretical framework and practical scheme for the connotation and quality improvement of manufacturing specialty in higher vocational colleges [4].

2. Current Situation and Problems

2.1 Imbalance Between Industrial Iteration and Specialty Construction

In the field of equipment manufacturing, the technology iteration speed continues to accelerate, new technologies such as intelligent equipment, digital twins and industrial big data continue to land in the enterprise production scene, and the post capacity standards continue to be updated. However, the specialty adjustment in higher vocational colleges has obvious lag, and the update cycle of specialty catalog, curriculum module and training project is too long, which can not synchronously match the new job demand of enterprises. Most colleges and universities have only added a small number of digital technology related class hours on the basis of the original traditional mechanical courses, and have not systematically reconstructed the talent training program. The cultivation of students' digital literacy and intelligent equipment practical ability is insufficient, graduates' job migration ability is weak, and enterprises' employment satisfaction is low [5].

At the level of school enterprise collaboration, most cooperation models are superficial. Colleges and enterprises have not established a normalized demand docking mechanism. New processes, new equipment and new job standards of enterprises cannot be quickly transformed into teaching resources. The breadth of industry education collaboration is insufficient, and it is difficult to form a virtuous cycle of professional reform driven by industrial demand [6].

2.2 Digital and Intelligent Construction Are Separated to form a Technology Island

At this stage, most higher vocational colleges promote digitization and intelligence as two independent tasks, which lack of linkage and coordination mechanism. Some colleges and universities separately purchased virtual simulation software to build a digital training platform, but did not connect with the real intelligent production line operation data of enterprises, and the simulation teaching was disconnected from the operation of physical intelligent equipment; Some colleges and universities have introduced intelligent production lines to carry out practical teaching, but they lack supporting digital modeling and data analysis teaching modules, and the teaching content is fragmented. The two types of construction resources operate independently, and the data are not connected to each other. The ability training of the teaching staff is also promoted in different ways [7-8]. Teachers either only master the development of virtual simulation teaching, or are only familiar with the operation and maintenance of physical intelligent equipment. At the same time, the reserve of dual qualified teachers with the combined ability of digital modeling and intelligent production line debugging is insufficient, which can not support the implementation of digital intelligent integration teaching.

2.3 Lack of Quantitative Evaluation Mechanism, Lack of Basis for Professional Dynamic Adjustment

The professional upgrading of existing colleges and universities mostly depends on the experience of teachers and sporadic visits to the industry to determine the adjustment direction. There is a lack of standardized and quantifiable evaluation index system, and it is impossible to accurately measure the matching degree between the major and the regional industry [9]. For key dimensions such as the depth of technology integration, the effectiveness of school enterprise cooperation, and the suitability of graduates' positions, there is no unified quantitative measurement standard. There is blindness in major adjustment, and it is difficult to achieve normalization and dynamic iterative optimization [10].

3. Implementation Path of Digital Intelligence Collaborative Upgrading of Equipment

Manufacturing Specialty

3.1 Professional Dynamic Adaptation Mechanism based on Digital Intelligence Upgrading

In view of the real pain point that the iteration of specialty construction lags behind the industrial reform and the lack of quantitative evaluation criteria for specialty optimization, this study takes the upgrading of digital intelligence as the main line, and constructs a specialty dynamic adjustment framework of "top-level construction orientation-core implementation system-construction effect output", so as to promote the real-time adaptation of specialty construction to the development of regional intelligent manufacturing industry, As shown in Figure 1.

The top-level construction orientation is closely linked to the regional development layout, industrial post demand and frontier technology iteration. Colleges and universities jointly carry out talent demand research with regional equipment manufacturing enterprises every year, and carry out quantitative calculation through five indicators, including specialty - industry matching rate, curriculum - cutting-edge technology synchronization rate, comprehensive utilization rate of training equipment, long-term competency rate of graduates' positions, and employment satisfaction of cooperative enterprises, to identify the deviation between specialty construction and industrial position demand; The reform effectiveness is evaluated from two dimensions: the depth of digital intelligent technology integration and the breadth of industry education cooperation. The former assesses the proportion and depth of the integration and implementation of digital courses and intelligent training projects in talent training, while the latter covers the content of school enterprise cooperation, such as enterprise project introduction, in school teaching of engineers, enterprise practice of teachers and students, and joint curriculum development.

The planning of regional leading industries, the trend of intelligent manufacturing technology, the endowment of colleges and universities, and the local vocational education policies constitute the bottom constraints, and define the appropriate boundary of professional reform. In the core implementation system, the operation mechanism, training mode and construction path are optimized and reshaped by optimizing the professional layout, innovating teaching mode, cultivating teachers' echelon, building professional clusters, cultivating compound technical and skilled talents, and building high-level scientific research teams. Relying on the linkage assessment implementation framework, colleges and universities dynamically adjust the professional direction, iterate digital intelligent courses and training projects, form a closed loop of "industrial research - index assessment - system implementation - professional optimization - effect feedback", realize regional radiation, demonstration and guidance, improve the level of talent training, and solve the problem of disconnection between talent supply and industrial demand.

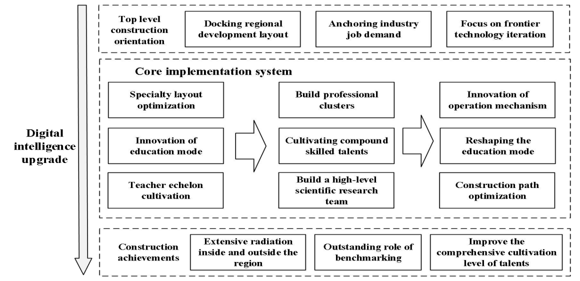

Figure 1. Digital Intelligence Upgrading Path of Equipment Manufacturing Specialty

3.2 "Five in One" Three Dimensional Virtual Simulation Teaching System Jointly Built by Colleges and Enterprises

The traditional physical training has many practical limitations, such as the high cost of large-scale equipment purchase and operation and maintenance, the irreversibility of high-risk practical operation links, the large consumption of production consumables, and the difficulty in realizing the full coverage of practical operation for all students. At the same time, the digital simulation teaching resources in most colleges and universities are separated from the physical intelligent production line, which cannot form a teaching closed loop. This research cooperates with regional equipment manufacturing enterprises to jointly build a three-dimensional virtual simulation platform integrating five functions of teaching, training, competition, production and scientific research, As shown in Figure 2. A four-layer progressive integrated architecture is built to open up the data interaction channel between digital teaching and entity intelligent production line. The bottom layer of the framework is the condition layer, and physical hardware terminals such as intelligent machine tools, industrial robots and various sensor devices are deployed. The second layer is the resource layer, which centrally stores digital twin equipment models, enterprise native process cases, equipment fault simulation materials and digital process files. The third layer is the platform layer, which integrates functional modules such as online teaching management, simulation operation exercises, production data interaction, and students' comprehensive assessment and evaluation. The top layer is the service layer, which provides integrated teaching service support for five application scenarios. The platform can support the teaching of digital basic skills such as intelligent equipment modeling and program debugging in daily classes, carry out digital process advanced training for on-the-job employees of cooperative enterprises, build a standardized simulation question bank for the preparation of intelligent manufacturing vocational skills competition, import the real processing work order of the enterprise to complete the virtual trial production to reduce the loss of physical trial production, and provide teachers and students with the ability to carry out process scientific research such as intelligent production line optimization and equipment fault diagnosis. In order to ensure that the content of the platform continues to fit the forefront of the industry, colleges and enterprises establish a normalized collaborative operation mechanism. The cooperative enterprises provide real process parameters of the intelligent production line and typical fault cases on the front line, and dispatch technical backbones of enterprises to serve as part-time training instructors. Colleges and universities are responsible for the development of simulation models, the transformation of teaching courses and the daily operation and maintenance update of the platform. After the implementation of new processes and new equipment, the case resource library of the platform is updated synchronously, and the problem of "technology island" formed by the disconnection between digital training resources and entity intelligent production scenes is completely solved.

3.3 "Double Platform, Four-Dimensional Experience" Double Helix Teaching Innovation Team Cultivation Mode

The implementation of digital and intelligent integrated teaching can not be separated from the support of double qualified teaching team with compound ability. Therefore, this paper constructs a double helix teacher growth model based on double platform support and covering four ability experience dimensions, and builds a hierarchical and progressive path to improve teachers' comprehensive ability with the deep linkage between schools and enterprises, as shown in Figure 3. The model sets up two types of complementary support platforms, i.e. on campus and off campus. An intelligent equipment technology research center is set up on campus to carry out normalized on campus teaching and research activities such as virtual simulation course development, intelligent equipment fault diagnosis, and digital process design for all teachers. The off campus linkage regional equipment manufacturing leading enterprises set up long-term and stable teacher enterprise practice bases, and arrange teachers to enter enterprises in stages to participate in real industrial projects such as intelligent production line transformation and digital process development, forming a two-way complementary cultivation carrier of on campus teaching and research precipitation and enterprise practice empowerment. The team cultivates the comprehensive professional ability of teachers around the four dimensions of industrial practice, competition guidance, curriculum development and scientific research, requires teachers to deeply participate in enterprise digital production projects to accumulate first-line practical experience, organizes teachers to lead teams to participate in intelligent manufacturing vocational skills competitions at all levels to polish the practical training guidance ability, and cooperates with enterprise engineers to jointly develop modular courses of digital intelligence integration, and forms an interdisciplinary teaching and research team to apply for teaching and technology research projects around core themes such as digital twins and intelligent equipment operation and maintenance. The whole cultivation system follows the ladder Growth Logic of "individual special skills strengthening - interdisciplinary team collaborative teaching and Research - school enterprise industrial ecology co construction". New teachers give priority to completing the special training of single skills such as digital simulation and intelligent device operation. Teachers with certain teaching experience form an interdisciplinary teaching and research team to cooperate in the development of digital and intelligent integration courses. Key teachers take the lead in docking school enterprise joint projects to deeply participate in the technological transformation of enterprises' industries. In the process of hierarchical cultivation, teachers' personal professional ability is improved, the overall quality of teaching teams is upgraded, and the school enterprise collaborative education system is improved, so as to continuously ensure that teachers' comprehensive ability matches the long-term upgrading and construction needs of professional digital and intelligent.

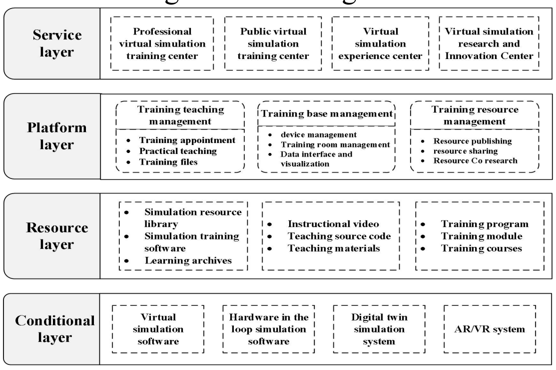

Figure 2. "Five in One" 3D Virtual Simulation System

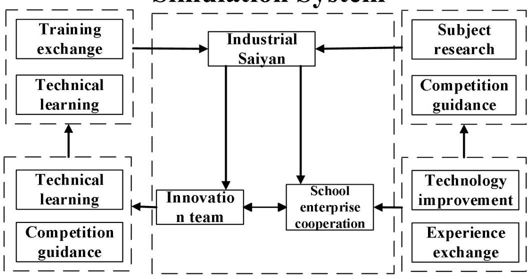

Figure 3. Implementation Path of High Level Teaching Innovation Team

4. Conclusion

Under the dual background of manufacturing power, digital China strategy promotion and new engineering education reform, the equipment manufacturing specialty in higher vocational colleges must change the traditional mode of digital and intelligent separate construction, and take the path of collaborative integration and upgrading. The professional dynamic adaptation mechanism, the five in one three-dimensional virtual simulation teaching system, and the dual platform four-dimensional experience and double helix teacher training mode constructed in this paper form an integrated collaborative upgrading scheme covering professional positioning, training resources, and the whole chain of teaching staff, which can effectively alleviate the structural contradiction of rapid industrial technology iteration and lagging response of vocational education personnel training, and continuously output compound digital craftsmen who adapt to the job requirements of smart factories.

Acknowledgments

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References

[1] Li S Z, Dong Z H, Deng C M. Thoughts on the System Architecture and Connotation of Digital Economy in the 14th Five-Year Plan Period. Information and Communications Technology and Policy, 2022, 48(1):24-31.

[2] Yin Y, Mao G Y. Mechanism and Path of Discipline-Major Adjustment and Optimization in Colleges and Universities from the Perspective of Complex Adaptive System. Academic Abstracts of Liberal Arts in Higher Education, 2026(4):138-139.

[3] Chen J H, & Wang D. Construction and practice of the "trinity" intelligent craftsman cultivation model in advanced manufacturing. Equipment Manufacturing Technology, 2026(3), 76-79.

[4] Wang H, Guo G Y, Yan Z Y. Research on Mechanism and Effect of Robot Application on Urban Carbon Emissions. Research on Financial and Economic Issues, 2023(5):52-63.

[5] Lu C Y. Upgrading and transformation of "digital+empowerment" mechanical manufacturing and automation major in Higher Vocational Colleges under the background of new quality productivity. Papermaking Equipment and Materials, 2025, (8):112-115.

[6] Li H, Li P, & Dou H C. Exploration and practice of industry-education integration in vocational education: A case study of the

Intelligent Manufacturing College of M College. Neijiang Science and Technology, 2026, 47 (3):78-81.

[7] Liu J G, Xie J L, & Liu W C. Exploration and practice of equipment manufacturing major construction mode under the guidance of "Double-high Plan": A case study of intelligent control technology professional group of Harbin Vocational and Technical University. Journal of Harbin Vocational and Technical College, 2026 (1), 1-3.

[8] Ao L M. Research on the high-quality development of "dual-qualified" teacher teams in higher vocational colleges from the perspective of new quality productive forces. Journal of Chongqing College of Electronic Engineering, 2025, 34(1):82-91.

[9] Yang C, & Cen Y J. Construction and application of competitiveness evaluation indicator system for specialty groups of higher vocational colleges under the background of "Double-high Plan". Vocational and Technical Education, 2024, 45(5), 76-80.

[10]Liu H, Gao Q, Li C, & Liu J. Research on the construction of intelligent manufacturing professional groups under the background of "industry-education integration". The Guide of Science and Education, 2024(23), 34-36.

