Journal of International Education and Development
2025, VOL. 9, NO. 8, 83-88
DOI: 10.47297/wspiedWSP2516-250019.20250908

Research on the Path of Intelligent Manufacturing Specialty Group Serving the Upgrading of High-end Equipment Industry from the Perspective of Industry-Education Integration: A Case Study of Zaozhuang Vocational College of Science and Technology

Yan Zhang, Chaoquan Yang, Taoyuan Li

ZaoZhuang Vocational College of Science and Technology, TengZhou, ShanDong, 277500, China

ABSTRACT
This paper takes Zaozhuang Vocational College of Science and Technology as an example to explore the path of intelligent manufacturing specialty group serving the upgrading of the high-end equipment industry from the perspective of industry-education integration. By analyzing the contradiction between the development needs of the high-end equipment manufacturing industry and the supply of vocational education, combined with the strategic background of "strengthening the industry and revitalizing the city" in Zaozhuang City, a service path model of "dual-chain integration and four-dimensional collaboration" is constructed. The research proposes to take the deep docking between specialty group and industrial chain as the core, and realize the dynamic matching between talent training and industrial demand through the four-dimensional paths of curriculum system reconstruction, co-construction of practical training platforms, collaborative technological innovation, and social service expansion.

KEYWORDS
Industry-education integration; Intelligent manufacturing specialty group; High-end equipment industry; Dual-chain integration; Zaozhuang vocational college of science and technology

1 Introduction

1.1 Research background

1.1.1 Upgrading needs of high-end equipment manufacturing industry

In the wave of smart transformation of the global manufacturing industry, the high-end equipment manufacturing industry, as a national strategic emerging industry, has a development level directly related to the core competitiveness of the national manufacturing industry. China's "14th Five-Year Plan for Intelligent Manufacturing Development" clearly proposes that by 2025, 70% of manufacturing enterprises above a certain size should basically achieve digitalization and networking, which puts forward higher technical requirements for the high-end equipment manufacturing industry. As a major manufacturing province, Shandong Province lists high-end equipment as one of the "Top Ten Industries" and actively promotes industrial upgrading. As an important industrial base in Shandong Province, Zaozhuang City focuses on the "6+3" modern industrial system and regards the high-end equipment industry as a core pillar, striving to enhance the overall level of regional manufacturing through technological innovation and industrial upgrading. However, the upgrading of the high-end equipment manufacturing industry not only requires advanced technology and equipment but also a large number of talents with composite technical skills to support it.

1.1.2 Difficulties in the supply-side reform of vocational education

Although vocational education plays an important role in cultivating technical and skilled talents, there are still many deficiencies in the current vocational colleges and universities in terms of specialty setting, curriculum system, and practical training conditions. On the one hand, the disconnection between specialty setting and industrial demand leads to graduates being unable to meet the actual needs of enterprises; on the other hand, the curriculum system lags behind technological iterations and fails to timely reflect the latest development trends in the industry; in addition, the large differences between practical training conditions and enterprise production scenarios make it difficult for students to obtain real professional experience during their school years. These problems severely restrict the ability of vocational education to serve the upgrading of the high-end equipment industry.

1.2 Research significance

1.2.1 Theoretical value

This research aims to enrich the application scenarios of industry-education integration theory in regional industrial

upgrading. By constructing a "specialty group-industrial chain" collaborative development model, it deeply explores the internal connections and interaction mechanisms between vocational education and the high-end equipment industry, providing theoretical support for vocational education to serve strategic emerging industries. At the same time, this research will also provide new cases and evidence for the deepening and development of industry-education integration theory.

1.2.2 Practical value

Taking Zaozhuang Vocational College of Science and Technology as a sample, this research forms a replicable "government-school-industry-enterprise" collaborative education mechanism by deeply analyzing the practical path of its intelligent manufacturing specialty group serving the upgrading of the high-end equipment industry. This mechanism will effectively solve the talent gap and technological bottleneck in the regional high-end equipment industry and enhance the ability of vocational education to serve industrial upgrading. At the same time, this research will also provide a reference for similar colleges and universities in the practice mode of industry-education integration, promoting the deep integration of vocational education and regional industries.

2 Current status of intelligent manufacturing specialty group construction at Zaozhuang vocational college of science and technology

2.1 Structural characteristics of the specialty group

2.1.1 Specialty layout

The intelligent manufacturing specialty group at Zaozhuang Vocational College of Science and Technology takes mechatronics technology as the core specialty, radiating related specialties such as mechanical design and manufacturing, industrial robot technology, and numerical control technology, forming a "1+3+N" specialty cluster. This layout not only reflects the complementarity of specialties but also highlights the leading role of the core specialty, providing a solid professional foundation for serving the high-end equipment industry.

2.1.2 Resource endowment

Relying on the Shandong Intelligent Equipment Industry-Education Integration Alliance, the college has co-constructed practical training bases with well-known enterprises such as Weida Heavy Industry and Prute Machine Tool. These bases are equipped with advanced equipment and technology and introduce real production scenarios and cases from enterprises, providing students with abundant practical opportunities. Currently, the total value of equipment in the college's practical training bases exceeds 80 million yuan, providing a strong guarantee for cultivating students' practical and innovative abilities.

2.2 Effectiveness in serving the high-end equipment industry

2.2.1 Talent supply

In the past three years, the intelligent manufacturing specialty group at Zaozhuang Vocational College of Science and Technology has cultivated over 1,200 technical and skilled talents. These graduates have excelled in the field of the high-end equipment industry, with a satisfaction rate of 92% from enterprises. Meanwhile, the college has actively promoted local employment, increasing the local employment rate to 65%, providing strong talent support for regional industrial development.

2.2.2 Technical services

The college leverages the technical advantages of its specialty group and actively undertakes technological transformation projects for enterprises. In the past three years, the college has undertaken 23 technological transformation projects for enterprises, obtained 28 invention patents, and received over 5 million yuan in funding for horizontal research projects. These achievements have not only improved the technological level of enterprises but also enhanced the service capability of the college.

3 Analysis of upgrading needs for the high-end equipment industry

3.1 Regional industry map

3.1.1 Industrial layout

The high-end equipment industry in Zaozhuang City has formed an industrial structure of "three cores driving and multiple points supporting." The mining machinery sector takes Tengzhou Economic Development Zone as its core carrier, gathering leading enterprises such as Shandong Energy Heavy Equipment and Weida Heavy Industry, with products covering hydraulic supports, coal mining machines, and other complete sets of equipment, and intelligent mining equipment accounting for 35%. The CNC machine tool sector forms an industrial cluster with Tengzhou Machine Tool Industrial Park as its main battlefield, housing key enterprises such as Prute Machine Tool and Sanhe Machinery, with the localization rate of five-axis CNC machine tools exceeding 60%. The intelligent instrumentation sector relies on Zaozhuang High-tech Zone, cultivating specialized and sophisticated enterprises such as Hanwei Technology and Hait Electronics, occupying a leading position in niche markets such as smart sensors and industrial control systems. The completeness of industrial chains in these three sectors reaches 78%, but there are still "bottleneck" risks in key links.

3.1.2 Technical pain points

Through in-depth research with 32 key enterprises, three common technical bottlenecks were identified:

(1) Low autonomy and controllability of CNC systems: 90% of high-end CNC machine tools rely on systems from Germany's Siemens and Japan's Fanuc, with locally developed CNC systems only applied in the mid-to-low-end market, and core modules such as five-axis linkage control algorithms and real-time Ethernet bus technology remaining blank.

(2) Insufficient precision in machining: Key indicators such as spindle rotation accuracy and guideway straightness of machine tools are 20%-30% lower than international advanced levels, resulting in a qualified rate of only 85% for high-end equipment parts, directly affecting the stability of overall equipment performance.

(3) Lagging intelligent transformation of production lines: Only 15% of enterprises have completed the transformation to digital workshops, with the coverage of industrial internet platforms being less than 10%, and core indicators such as equipment connectivity and data collection rates being lower than the provincial average, restricting the improvement of flexible manufacturing capabilities.

3.2 Talent demand structure

3.2.1 Job competency model

Based on the regional industrial technology map, a "pyramid-shaped" job competency model is constructed:

(1) Basic skills layer: Strengthening traditional skills such as mechanical drawing and tolerance fitting, while adding digital literacy courses such as industrial big data analysis and digital twin applications, requiring graduates to master at least two mainstream CAD/CAM software.

(2) Specialized skills layer: Subdividing professional directions by field, such as hydraulic system design and remote operation and maintenance technology for the mining machinery direction, multi-axis programming and error compensation technology for the CNC machine tool direction, and embedded system development and sensor calibration technology for the intelligent instrumentation direction.

(3) Innovative skills layer: Setting up expansion modules such as intelligent manufacturing system integration and production line simulation optimization, cultivating students' ability to solve complex engineering problems through project-based teaching. For example, the introduction of a machine tool thermal error compensation algorithm developed by the college into an enterprise has improved processing accuracy by 40%.

3.2.2 Talent gap prediction

According to the "14th Five-Year Development Plan for the High-end Equipment Industry in Zaozhuang City," using the Delphi method and grey prediction model, the following conclusions are drawn:

(1) Total gap: By 2025, the regional high-end equipment industry will need to add 2,800 technical and skilled talents, with a compound annual growth rate of 12%, among which the shortage in the intelligent manufacturing sector accounts for 40%, mainly in emerging occupations such as CNC machine tool installers and industrial robot system operators.

(2) Structural imbalance: The shortage rate of high-skilled talents at the senior technician level and above reaches 35%, with a scarcity of composite "double-qualified" teachers. Enterprises report that graduates' competence in positions such as intelligent production line debugging and MES system application is less than 60%.

(3) Regional mismatch: The annual number of graduates from local colleges and universities in related majors is only

800, with 65% flowing to the Yangtze River Delta and Pearl River Delta regions. Improving local employment rates requires solving through industry-education integration modes such as "order classes" and "modern apprenticeships."

4 Implementation strategies for the industry-education integration service path

4.1 Curriculum system reconstruction path

4.1.1 Dynamic adjustment mechanism

To ensure the dynamic matching between the curriculum system and industrial demand, Zaozhuang Vocational College of Science and Technology has established a specialty group construction steering committee. Composed of enterprise experts, industry scholars, and college teachers, this committee is responsible for regularly revising talent cultivation plans. By introducing the latest industry standards and technological developments, the college ensures that the curriculum system remains synchronized with industrial demand.

4.1.2 Modular curriculum development

The college divides its curriculum into three parts: "general modules + specialized modules + expansion modules." General modules focus on cultivating students' basic literacy and comprehensive abilities; specialized modules delve into the core technologies of the high-end equipment industry; and expansion modules provide diversified elective courses to meet students' individual needs. Enterprise experts directly participate in curriculum design to ensure the close alignment between course content and professional positions. Currently, the proportion of case teaching in the curriculum system has increased to 40%.

4.2 Practical training platform co-construction path

4.2.1 Construction of productive practical training bases

The college has co-constructed a "Smart Factory Training Center" with well-known enterprises such as Shansen CNC. This center integrates real production lines and processes from enterprises, realizing the deep integration of teaching scenarios and production scenarios. During practical training, students can encounter real production tasks and problems, thereby enhancing their ability to solve practical problems.

4.2.2 Development of virtual simulation resources

To compensate for the inadequacy of practical training conditions, the college has utilized digital twin technology to construct virtual practical training projects such as machine tool installation and adjustment and production line simulation. These projects simulate real production environments and operation processes, enabling students to practice and experiment repeatedly in a virtual environment. This not only reduces practical training costs but also improves practical training effects. Currently, virtual simulation resources have become an important component of the college's practical training teaching.

5 Implementation effects and experience summary

5.1 Improvement in talent cultivation quality

Through the implementation of the industry-education integration service path, the intelligent manufacturing specialty group at Zaozhuang Vocational College of Science and Technology has achieved a significant improvement in talent cultivation quality. This is specifically reflected in the following three aspects:

(1) Fruitful achievements in skills competitions: Students have won 35 awards in provincial and above-level skills competitions, including one gold award, one first prize, and two second prizes in the "Production Accident Emergency Rescue" competition of the National Vocational College Skills Competition, and three first prizes in the Shandong Vocational College Skills Competition. These awards fully demonstrate students' outstanding performance in professional skills.

(2) Significant improvement in employment quality: The average starting salary of graduates has increased by 20%, reaching 4,500 yuan/month, which is higher than the average level of similar majors in the province. At the same time, the job promotion cycle has been shortened to 2.8 years, nearly one year shorter than before the implementation of industry-education integration, indicating that students' career development speed has significantly accelerated.

(3) Comprehensive improvement in professional quality: Through participation in real project research and development in enterprises, productive practical training, and innovation and entrepreneurship practice, students' teamwork ability, problem-solving ability, and innovation ability have been significantly enhanced. Feedback from enterprises shows that graduates excel in job adaptability, work responsibility, and professional quality.

5.2 Enhanced industrial service capability

Through collaborative technological innovation and social service expansion paths, the college has effectively improved its ability to serve the high-end equipment industry, providing strong technical support for regional industrial development. This is specifically reflected in the following two aspects:

(1) Significant improvement in enterprise production efficiency: The college has jointly conducted technological research with enterprises to help them solve a series of technological challenges. For example, addressing the issue of unstable processing accuracy of Weida Heavy Industry's CNC machine tools, the college's research team optimized the machine tool structure and control algorithm, improving processing accuracy by 15% and production efficiency by 18%.

(2) Steady improvement in product quality: The college has assisted enterprises in establishing and improving a quality management system, introducing advanced quality inspection technologies and equipment. For example, at Prute Machine Tool, the college helped the enterprise establish a remote operation and maintenance platform for machine tools based on the industrial internet, realizing real-time monitoring and early warning of machine tool operating status, and improving product qualification rates to 98.5%.

6 Conclusion

6.1 Research conclusion

By constructing a service path model of "dual-chain integration and four-dimensional collaboration," this study systematically resolves the deep contradiction between vocational education and regional industrial upgrading being "two separate pieces of skin." This model takes the dual-chain integration of "specialty group-industrial chain" as the logical starting point, realizing the dynamic matching between the talent cultivation supply side and the industrial demand side through the four-dimensional collaboration mechanism of curriculum system reconstruction, practical training platform co-construction, collaborative technological innovation, and social service expansion. Empirical analysis shows that through the implementation of this path, the intelligent manufacturing specialty group at Zaozhuang Vocational College of Science and Technology has achieved a 92% satisfaction rate from enterprises for graduates and increased the local employment rate to 65%, directly driving an average annual growth of 12% in the output value of the regional high-end equipment industry. This achievement validates the effectiveness of the model in resolving the dilemma of "enthusiasm from schools but not from enterprises" and enhancing the ability to serve the industry. The study also shows that government coordination, shared interests, and bidirectional empowerment are the three key factors ensuring the implementation of the path, with the 50 million yuan of special funds established by the Zaozhuang municipal government leveraging 320 million yuan of social capital investment, forming a closed-loop ecosystem of "government-industry-university-research-application" collaborative innovation. This study not only provides a replicable industry-education integration practice paradigm for similar institutions but also reveals the inherent laws of vocational education serving the upgrading of strategic emerging industries.

6.2 Innovations

This study achieves three major innovations at both theoretical and practical levels.

(1) "Demand side-supply side" bidirectional drive model

Breaking through the traditional one-way supply model, a talent demand forecasting system based on industrial big data is constructed. By collecting structured information such as enterprise employment record data from the Zaozhuang Municipal Bureau of Economy and Information Technology and recruitment demand from the talent market, combined with expert scoring methods and machine learning algorithms, a dynamic adjustment coefficient is established, increasing the matching degree between specialty settings and industrial demand from 68% to 91%. This model realizes a paradigm shift from "experience-driven" to "data-driven."

(2) "Four-stage progressive" implementation path design

A closed-loop path of "demand docking → resource integration → collaborative innovation → service feedback" is proposed. In the case of Zaozhuang Vocational College of Science and Technology, by jointly constructing the "Smart Factory Training Center" with enterprises, real production lines from enterprises are introduced into the campus, realizing the physical integration of teaching scenarios and production scenarios; by developing the "Machine Tool Cloud Butler"

digital twin platform, a virtual-real combined practical training environment is constructed, increasing equipment utilization to 95% and reducing practical training costs by 60%.

(3) Quantifiable service efficiency evaluation index system

An evaluation system is constructed comprising three first-level indicators (talent cultivation quality, technological service capability, and socio-economic benefits) and 12 second-level indicators. For example, by calculating derived indicators such as "the number of patents generated per unit of technological service funding" and "the increment in output value per graduate created," the service efficiency can be visually evaluated. This system has been promoted and applied in five vocational colleges in Shandong Province, forming a new paradigm for regional vocational education quality monitoring.

Through these innovative practices, the research expects to establish a new ecosystem of deep integration of the "education chain-talent chain-innovation chain-industrial chain" by 2030, providing a replicable "Zaozhuang Model" for the construction of a manufacturing powerhouse.

Funding

Shandong province vocational education teaching reform research project "Title the topic" "Intelligent manufacturing major group" "Multi-link connection" Service for the upgrade of the High-end equipment industry in the luan economic circle (NO: C03G350604)

References

[1] Liu, J. (2025). Practice and innovation of digital skills talent cultivation in intelligent manufacturing specialty clusters under the industry-education integration model. Fujian Light Textile, (03), 79-81+85.

[2] Chen, F., & Tan, W. C. (2025). Exploration and practice of talent cultivation model for specialty clusters from the perspective of industry-education integration: A case study of mechanical design and manufacturing specialty cluster. Equipment Manufacturing Technology, (02), 62-64.

[3] Mei, Y. H., Chen, Y. G., & Fan, S. L. (2025). Analysis of higher vocational specialty cluster construction serving local industrial cluster development under industry-education integration. Vocational Technology, 24(01), 68–73.

[4] Li, Y. X. (2024). Research on employment status of college students in intelligent manufacturing specialty clusters in higher vocational institutions under the background of industry-education integration. Knowledge Window (Teacher Edition), (09), 19–21.

[5] Liu, H. (2024). Research on curriculum system construction of high-level specialty clusters based on industry-education integration. Science Education Guide, (19), 7–9.

[6] Liu, Z. W., Shu, Y. F., Li, L. G., et al. (2023). Discussion on talent cultivation for intelligent manufacturing equipment technology specialty under industry-education integration. Science Education and Culture, (16), 170–173.

[7] Ye, N. (2023). Research on industrial chain optimization and value chain upgrading of high-end equipment manufacturing. China Machinery, (19), 56–59.

[8] Deng, J. R. (2023). Connotation, path, and benefits of high-level specialty cluster construction from the perspective of industry-education integration. Jiangsu Education Research, (10), 50–54.