VTE VOCATION, TECHNOLOGY & EDUCATION

ORIGINAL RESEARCH

A three-tier integrative model of industry-education collaboration: Innovative practice from Shenzhen Polytechnic University

Li Yuan[1], Ting Wen[2], Danlei Lin[3,*]

[1]Institute of Technical and Vocational Education, Shenzhen Polytechnic University, Shenzhen 518055, Guangdong Province, China
[2]Center of News and Publicity, China Academy of Chinese Medical Sciences, Beijing 100700, China
[3]School of Education, Guangzhou University, Guangzhou 510006, Guangdong Province, China

Abstract

Industry-education integration is central to vocational education, yet many programs still face a structural gap between classroom learning and industrial practice. This study examines the School of Artificial Intelligence at Shenzhen Polytechnic University (SZPU) as a case of industry-education integration in artificial intelligence education. Adopting a qualitative case study design, the study analyzes institutional documents, program materials, school-enterprise cooperation records, and publicly available policy and project information to explore how a three-tier integrative model was developed and implemented. The findings show that the model operates through three interconnected layers. The physical layer involves shared laboratories, micro-factory environments, and online-offline training platforms that embed industrial technologies into teaching. The institutional layer includes curriculum-certificate integration, dual-track hierarchical training, enterprise participation, and multi-stakeholder quality assurance mechanisms. The cognitive layer emphasizes joint curriculum development, collaborative research platforms, and shared innovation goals between the school and industry partners. The case suggests that effective industry-education integration requires not only resource sharing but also institutional coordination and cognitive alignment. This study contributes to vocational education research by offering a layered framework for understanding the deepening of school-enterprise collaboration, while providing practical and policy implications for building sustainable cooperation ecosystems in emerging technology fields.

Keywords

industry-education integration, three-tier model, physical-layer cooperation, institutional-layer cooperation, cognitive-layer cooperation

INTRODUCTION

The integration of industry and education is a core feature of vocational education because vocational programs are expected to respond to labour-market demand and prepare learners for occupational practice (OECD Reviews of Vocational Education and Training, 2010). Although policies at the national level—such as China's 14th Five-Year Plan—have established a strategic framework, the implementation rules at the provincial and local levels remain insufficient (National Development and Reform Commission, 2021). Local governments tend to prioritize large-scale economic development projects, while the technical needs of small and medium-sized enterprises may receive comparatively less attention in the design and implementation of industry-education integration policies. In

***Corresponding Author:**
Danlei Lin, School of Education, Guangzhou University, No. 230, Xiaoguwei Street, Panyu District, Guangzhou 510006, Guangdong Province, China.
Email: 1449426901@qq.com; https://orcid.org/0009-0006-9433-351X
Received: 1 December 2025; Revised: 25 February 2026; Accepted: 16 June 2026
https://doi.org/10.54844/vte.2025.1109

addition, existing policies often focus on the supply side and ignore demand-side incentives, resulting in low enterprise participation and a mismatch between educational content and industrial needs (Han, 2024). Against the background of industrial transformation driven by the digital economy, deepening industry-education integration has become an important strategy for aligning vocational education with the changing skill demands of industrial upgrading (Xinhua, 2022; Yang, 2023).

As a vocation university, Shenzhen Polytechnic University (SZPU) has developed a three-tier integrative industry-education collaboration model through the Artificial Intelligence Engineering Technology program at the School of Artificial Intelligence (2024). The three tiers comprise the physical layer (hardware and technology co-construction), the institutional layer (bilateral empowerment coordination mechanism), and the cognitive layer (target collaborative value co-creation). The model is driven by a demand-transformation mechanism through which enterprise skill needs, production tasks, and technological updates are translated into curriculum modules, training scenarios, certification requirements, and applied research topics. The three tiers are progressively connected: The physical layer integrates equipment, laboratories, and production-like training spaces; the institutional layer integrates curriculum design, certification standards, teaching responsibilities, and quality assurance; and the cognitive layer integrates shared problem definitions, innovation goals, and knowledge co-creation between the school and enterprise partners. This innovative model not only facilitates the seamless connection between talent cultivation and industrial needs but also forms a large-scale, replicable professional experience, providing a development paradigm with both theoretical depth and practical effectiveness for vocational undergraduate education.

SZPU is located in Shenzhen, a major industrial and technological city in southern China. Shenzhen's rapid development was closely associated with China's reform and opening-up policy, particularly the establishment of the Shenzhen Special Economic Zone in 1980. As one of China's first Special Economic Zones, Shenzhen was granted more flexible economic policies to attract foreign investment, experiment with market-oriented reforms, and promote export-oriented industrial development (Our China Story, 2024). Shenzhen maintains a leading position in national economic rankings and serves as a primary base for high-tech industries, hosting internationally renowned corporations such as Huawei, Tencent, and BYD Company Limited (BYD). Furthermore, the city benefits from special preferential economic policies that foster an institutional environment that is conducive to the integration of industry and education in vocational programs. Situated within the Guangdong-Hong Kong-Macao Greater Bay Area—one of China's most dynamic clusters of emerging industries—SZPU consistently adheres to an industry-oriented and application-centered educational philosophy (Central Committee of the Communist Party of China & The State Council, 2019). Supportive national and regional policies have created a favorable external environment for enterprise participation in vocational education, while also providing SZPU with new opportunities for industrial collaboration. To this end, SZPU established the School of Artificial Intelligence in 2019, focusing on frontier fields such as artificial intelligence (AI), big data, cloud computing, and virtual reality (School of Artificial Intelligence-Shenzhen Polytechnic University, 2024). The university invested RMB 230 million in advanced training facilities and jointly established 21 laboratories in partnership with leading enterprises (School of Artificial Intelligence-Shenzhen Polytechnic University, 2024; Shenzhen Polytechnic University, 2019). Furthermore, 75% of the curriculum in traditional disciplines, including software technology, was upgraded with intelligent components (Admissions Website-Shenzhen Polytechnic University, 2024).

By employing a dual-track strategy that integrates new-discipline development with the modernization of traditional programs, SZPU has established a vocational education system aligned with the AI industrial chain. This strategy positions AI as a strategic driver of the university's recent transformation (Shenzhen Polytechnic University, 2019). Accordingly, the Artificial Intelligence Engineering Technology program aims to cultivate skilled technical professionals specializing in service and operations who can adapt to the widespread application of AI technologies across diverse current and future scenarios.

From an enterprise perspective, collaboration with SZPU offers several strategic advantages. Such partnerships enable enterprises to participate directly in workforce development and to cultivate technically proficient graduates whose skills are more closely aligned with enterprise needs. For example, SZPU has partnered with leading enterprises, including Huawei and BYD, to establish 17 industry-oriented colleges (Luo, 2026). These partnerships are organized around a nine-pillar cooperation framework, covering Party-building cooperation, project development, curriculum design, Research and Development (R&D) center construction, faculty development, vocational qualification certification, entrepreneurship education, modern apprenticeships, and international cooperation (Mei *et al*., 2024). Through this bilateral participation model, schools and enterprises jointly contribute to talent cultivation, technical training, and applied innovation, thereby strengthening the human resources and technical support available for regional industrial development.

Furthermore, enterprise involvement in collaborative research—including industry standard formulation, technology incubation, and key technical challenges—accelerates innovation, promotes the transformation of scientific research results, and improves market competitiveness. By resolving practical technical issues, enterprises can strengthen their core innovation capabilities and consolidate their competitive advantage. Finally, continuous collaboration with SZPU enables enterprises to establish brand influence in different regions and demonstrate leadership in the field of vocational education, thereby extending their educational reach and maintaining industry prominence.

The Artificial Intelligence Engineering Technology program within the School of Artificial Intelligence maintains extensive partnerships with industry leaders, such as SmartMore Corporation Limited (SmartMore). Guided by principles of industry-demand orientation, comprehensive resource sharing, and the integration of technical feedback into the curriculum, these collaborations facilitate the development of a professional platform and the dynamic adjustment of talent cultivation models. The result is a multi-level and multi-dimensional collaborative education system and a refined model of industry-education integration (Table 1). While the goals of academia and industry may diverge, these differences foster a complementary collaborative space, ensuring that project development upholds the principles of education while remaining highly responsive to technological change.

The development of SZPU's three-tier integrative model of industry-education integration was driven by multiple interdependent factors. First, the industrial revolution precipitated a transformation on the educational supply side. The deep integration of AI with manufacturing has resulted in a surge of demand for interdisciplinary professionals skilled in technologies such as intelligent vision, data analytics, and industrial software. However, traditional theory-based instruction often fails to meet industry demands for applied technological competence, leaving students trapped in a persistent learning-application gap.

Second, the reconfiguration of educational resources facilitates the reform of talent cultivation systems. As the School of Artificial Intelligence transitioned to the undergraduate vocational level, three major challenges emerged: Insufficient physical capacity in training spaces, a lack of high-end equipment, and disjointed curriculum module alignment. For example, in the Computer Vision Applications course, the absence of industrial-grade training equipment resulted in abstract and detached instruction, hindering the achievement of the program's goal to cultivate high-quality, application-oriented professionals. This disconnection between teaching and practice has significantly constrained educational effectiveness, leading to a structural mismatch between educational objectives and industrial demands.

Third, the pursuit of mutual interests among diverse stakeholders serves to fortify the regional industrial ecosystem. Through a cooperative model comprising enterprise equipment donations and university-led research and development, both parties can establish a seamless link among industry, academia, and research. The university gains access to advanced equipment, real-world cases, and industry mentors, thereby enhancing faculty expertise and research translation capacity. Simultaneously, enterprises leverage the university's platform to promote technical standards and cultivate a pipeline of skilled talent.

ANALYSIS AND PRACTICAL OUTCOMES

SZPU's Artificial Intelligence Engineering Technology program collaborates with SmartMore along the main axes of demand transformation, tiered cultivation, and ecosystemic collaboration. Driven by the joint forces of brand building, technological application, and industrial demand, both parties have identified opportunities for cooperation to establish a sustainable and synergistic ecosystem. The partnership transitioned through three stages: An initial phase focused on physical equipment and technology sharing; an intermediate phase emphasizing the development of institutional rules, and an advanced phase centered on transforming knowledge innovation models. This reflects an evolutionary progression from physical to institutional and, finally, cognitive collaboration, demonstrating a deepening trajectory from basic cooperation to advanced synergy.

Physical collaboration between industry and education

The following sections examine the three layers of SZPU's industry-education integration model in turn. The physical layer refers to the material and technological foundation of collaboration, including shared laboratories, equipment, training platforms, and simulated production environments. At this layer, cooperation between vocational institutions and enterprises is primarily realized through the joint construction and use of training spaces and technical resources.

Strengthening physical infrastructure and the organizational capacity for collaboration provides a foundation for connecting the education chain, talent chain, industry chain,

Table 1: Comparison of SZPU three-tier integration model and the conventional order-based training model

Dimension	Conventional order-based training model	SZPU three-tier integration model	Practical implications
Policy support	Lack of systematic policies	Government-led industrial cluster alignment	Local governments, vocational institutions, and enterprises can coordinate policies according to regional industrial needs
Cooperation	Unidirectional talent delivery; minimal participation in cultivation process	Enterprises establish micro-factories and micro-workshops in schools; technology sharing and joint R&D platforms	Enterprises bring micro-factories to schools; enterprise mentors participate in practical training
Areas of cooperation	Employment-oriented; single cooperation area	Enterprise participation in curriculum development, talent cultivation planning, and practical course leadership; expanding employment channels	Extensive school-enterprise partnerships and collaboration chains; sustainable ecosystems
Cooperation characteristics	Project-based; development of production line operational capabilities	Full-chain cooperation in R&D, curricula, and certification; cultivation of innovation and core technology transfer capabilities	Training can shift from narrow job adaptation to broader technical competence and innovation capacity
Resource investment	Unilateral school investment	Schools provide platforms while enterprises provide technology and personnel; enterprise technology sharing	Both parties seek collaborative opportunities with win-win outcomes
Applicable scope	Labor-intensive industries	Technology-intensive industries	Modern industries with high skill demands

SZPU, Shenzhen Polytechnic University; R&D, Research and Development.

and innovation chain (Zhang & Gu, 2021). It also creates workplace-like learning opportunities in which students can engage with authentic tools, tasks, and feedback (Billett, 2001; Guile & Griffiths, 2001). Against the backdrop of AI industrial chain reconstruction, SZPU and SmartMore implemented a strategy of physical-layer integration. By aligning corporate brand development with university talent cultivation, both parties replicated key elements of industrial production within the teaching envi-ronment by bringing enterprise equipment, workflows, and production scenarios into on-campus laboratories, so that classrooms could also function as training workshops and enterprise testing spaces. This model established an experimental platform for enterprise technology upgrading while creating a market-oriented paradigm for talent cultivation, thereby optimizing resource allocation.

To address the disconnection between theoretical knowledge and practical application, SZPU and SmartMore established an industrial vision detection laboratory and an AI miniature scene training laboratory on campus. The former is equipped with high-performance computers, NVIDIA Jetson and Huawei Ascend (Shengteng) development boards, and industrial cameras to support digital image processing, computer vision, deep learning curricula. The latter features industrial cameras, optical lenses, six-axis robotic arms, and defect detection software for training in machine learning, reinforcement learning, and intelligent voice technology. These labora-tories function as micro-factories that simulate authentic industrial environments, where enterprises contribute technical expertise and universities provide human capital and resources to form a mutually beneficial partnership.

This approach integrates the technical standards of leading manufacturing enterprises into the training process, building a full-cycle model of talent training of theory-practice-evaluation and effectively solving the problem of disconnection between traditional vocational education and industrial practice. At the implementation level, the enterprise develops an online-offline integration (OMO) intelligent training platform. The online component uses virtual simulation to support activities such as process-parameter optimization and digital-twin debugging, while the offline component relies on micro-factory laboratories and industrial equipment for hands-on training. Together, these components help students connect theoretical knowledge with applied skills in intelligent manufacturing scenarios (SmartMore Corporation Limited, 2023). This OMO model enables students to convert theoretical knowledge into applied skills and accelerates their transformation into skilled professionals in the field of intelligent manufacturing.

The primary innovation of this partnership is the technical transformation of education through industry-education integration. The underlying logic of industrial demand feeding back into education effectively resolves the structural contradictions between enterprise employment needs and educational training goals. This model employs a market demand-based screening mechanism—led by a professional training team—to identify key areas such as intelligent manufacturing and machine vision.

In the practical reinforcement stage, SZPU and SmartMore developed micro-factory training scenarios that incorporate equipment and applications such as intelligent sensors, machine vision systems, and digital factory simulations (SmartMore Corporation Limited, 2023). These scenarios are not created by the model itself, but through the joint work of university teachers, enterprise engineers, and training teams who transform industrial tasks into teachable modules and practice-oriented activities. As new AI platforms, virtual simulation tools, and industrial cases are introduced by enterprise partners, the curriculum can be updated accordingly. In this way, the physical layer establishes a mechanism through which industrial technologies are continuously converted into teaching content, training tasks, and practical learning environments. This helps reduce the gap between classroom-based learning and industrial practice.

Institutional-layer integration: Building a dual-empowerment collaborative education mechanism

The primary objective of deepening industry-education integration is to enhance enterprise participation in educational activities and implement a comprehensive university-enterprise co-education model (General Office of the State Council of the People's Republic of China, 2017). Upon entering the second phase of its integration development, the School of Artificial Intelligence at SZPU shifted its focus toward establishing a systemically coupled institutional mechanism. Building on the physical-layer collaboration described above, the School of Artificial Intelligence at SZPU further developed institutional-layer collaboration by establishing three mechanisms: A tiered curriculum-certificate integration system, a dual-track talent cultivation model, and a multi-stakeholder teaching quality assurance system. These three mechanisms are discussed in turn below.

A tiered and categorized curriculum-certificate integration system was developed by SZPU and its partner institutions. The talent cultivation framework was co-designed by several renowned universities and enterprises, including Sun Yat-sen University, Wuhan University, Central South University, and Shenzhen SmartMore. The overall curriculum emphasizes practical application while maintaining a comprehensive knowledge structure, integrating theoretical learning with applied practice to meet industrial needs. Moreover, enterprise certifications—such as the Huawei ICT Certification—were incorporated into the curriculum design. This system embeds certification standards into syllabi, certification modules into classrooms, and certification assessments into credit recognition. This ensures that course content remains aligned with evolving industry technologies. Instruction is jointly delivered by university faculty and enterprise experts.

A dual-track teaching system was implemented. In this context, the curriculum system refers to the ordered set of theoretical courses, project-based practical modules, enterprise training tasks, and certification-related requirements jointly designed by SZPU and its enterprise partners. It combines theoretical progression with staged practical training and follows the principles of parallel promotion and hierarchical learning. The practical course follows a three-stage development path: First-year students engage in AI edge development, second-year students carry out edge comprehensive project practice, and third-year students focus on cloud optimization and applied knowledge. Each stage combines theory and practice and emphasizes mastering key technologies—including signal processing, deep learning model development and optimization, database design and management, and digital image processing—to establish a solid foundation for students' professional development.

A multi-stakeholder teaching quality assurance system was established. The system emphasizes collaboration with enterprise partners to supervise to provide feedback on practical instruction. It improves teaching quality by regularly organizing public classes, demonstration sessions, special seminars, and other teaching and scientific research activities. A quality assurance committee—comprising project leaders, core teachers, industry experts, and external experts—ensures comprehensive quality control across all stages of professional education. The system covers classroom teaching, teaching evaluation, internship and practical training, graduation design, curriculum research, project updates, and resource development. Through classroom observation, teaching evaluation, and peer review, the committee leverages the professional knowledge of the school-enterprise advisory committee to ensure continuous improvement.

SZPU and its enterprise partners established a dual-track talent cultivation model. Within this university-enterprise framework, both parties assume different responsibilities to jointly construct the system. The university manages theoretical teaching modules, including foundational and core courses, providing students with a solid theoretical base. It regularly updates teaching standards to ensure alignment with industrial demands and evolving trends. The university also designs a course-certification integration mechanism, embedding certification content into the curriculum framework to connect academic education with vocational qualification standards. Concurrently, enterprises provide practical teaching modules, such as optical equipment operation and algorithm debugging, enabling students to apply theoretical knowledge to authentic industrial scenarios. By leveraging enterprise facilities and technical resources, the curriculum spans terminal, edge, and cloud technologies, aligning with the industry skill matrix to form a theoretical input-project output closed loop. This coordinated division of labor allows universities and enterprises to jointly cultivate AI professionals possessing both theoretical and practical ability, realizing the deep coupling of education, talent, and industrial chains.

The second institutional mechanism is a multi-stakeholder quality evaluation system. To achieve optimal evaluation outcomes in a university-enterprise collaboration, it is crucial to clarify the responsibilities of all parties. Thus, a multi-stakeholder evaluation system is required. The university implements enterprise and graduate evaluation systems while introducing third-party assessment mechanisms that focus on students' adaptability, practical competence, and knowledge application. Under the guidance of the Quality Diagnosis and Improvement Committee, the university continuously optimizes training objectives and curriculum systems based on four types of data: Industry research, graduate tracking, enterprise feedback, and technology monitoring. At the same time, teachers conduct regular industry research to dynamically adjust program content and curriculum design. By combining teaching platform data and student behavioral analytics, big data technology is used to optimize personalized learning services. Enterprises are required to provide regular feedback on graduates' work performance, share updated industry talent demands, and participate in curriculum co-development by providing typical production cases to ensure course content aligns with job requirements. Graduates are encouraged to take part in follow-up surveys to report on career progress and offer suggestions for curriculum improvement. Third-party institutions assess the alignment between talent cultivation quality and social demand through scientific methodologies. Maintaining regular feedback channels across these stakeholders helps connect talent cultivation with industrial needs and supports continuous improvement in collaborative education quality.

Cognitive-layer integration: Building a university-enterprise collaborative innovation ecosystem

The deepening of the integration of industry and education has reached the cognitive level, signaling that value co-creation has reached a higher level. This stage transcends the traditional model of cooperation, emphasizing strategic mutual trust and innovation based on knowledge and skills.

Through the calibration of shared values, the project optimizes industrial docking and positioning. The AI project at the undergraduate level focuses on the basic layer of the industrial chain and cultivates technical service and operational talent rather than high-end R&D talent to meet the needs of the midstream industry. This positioning responds to a common challenge in technology-intensive industries: Industrial technologies are updated faster than conventional curriculum systems canadapt.

According to Zhuang (2018), the profit- and efficiency-driven nature of industrial systems creates continuous demand for technological, market, and managerial innovation. Such innovation is problem-oriented, emerging from real challenges and developmental opportunities in areas such as production, management, marketing, and operations. In terms of knowledge innovation and transformation, the university and enterprises align the education and industrial chains through job profile analysis and joint curriculum development.

Additionally, a joint research and development platform was established to ensure that talent training would be accurately connected with the needs of enterprises. From a boundary-crossing perspective, such platforms can function as shared spaces where school and enterprise actors coordinate different forms of knowledge, practice, and professional identity (Akkerman & Bakker, 2011; Wenger, 1998). Cognitive integration not only promotes professional development in higher-technology fields but also encourages the establishment of new institutions such as joint research and development innovation centers between vocational colleges and universities and leading enterprises. Joint curriculum development, job-profile analysis, and collaborative research platforms helped connect talent cultivation with enterprise technology needs.

At the cognitive-integration stage, the School of Artificial Intelligence at SZPU has generated several project-level outcomes. It has co-established joint laboratories and research centers with major enterprises such as Huawei (including the Huawei Cloud Academy Kunpeng Center) and Yinsheng Group, building a cooperation mechanism that links technological R&D, teaching transformation, and talent supply. Regionally, the school has partnered with local institutions such as Pengcheng Laboratory to promote the application of smart city technologies and to convert outputs such as intelligent detection models into teaching resources (School of Artificial Intelligence-Shenzhen Polytechnic University, 2024). These outcomes indicate a closer institutional connection between talent cultivation, teaching resources, and enterprise technology needs.

The core innovation is achieving an upgrade of industry-education convergence—from physical integration to cognitive integration. The university promotes the advancement of industry-education cooperation by expanding the dimensions and levels of collaboration, facilitating the evolution from initial physical integration to advanced cognitive integration. As the foundational stage of industry-education integration, physical integration focuses on shared infrastructure construction, with typical models including the joint establishment of miniature intelligent training laboratories and open practice workshops. The university takes the lead in forming professional construction committees that include industry experts, incorporating the latest industrial standards dynamically into the curriculum system. Modular course packages (such as 1 + X certificate programs) are developed, and a dual-mentor system is implemented, inviting enterprise technical experts to serve as practice mentors. The university also invests in the development of smart classrooms and virtual simulation training centers. On the enterprise side, companies open their R&D centers and production workshops as teaching factories, establish specialized internship positions and tiered internship systems, and set up scholarships and skill competition funds. In terms of collaborative innovation, both sides jointly establish industrial colleges or innovation centers, apply for major research projects, and form dual-body management committees. This layered cooperation model shows a progressive deepening of collaboration from resource sharing to institutional coordination and knowledge co-creation, effectively addressing the long-standing disconnection between vocational education and industry. Through such deep collaboration, both sides work together to build a sustainable new ecosystem for industry-education integration, achieving the genuine three-level leap from the physical layer to the institutional layer and finally to the cognitive layer.

IMPLICATIONS FOR VOCATIONAL EDUCATION

Based on the case of SZPU's Artificial Intelligence Engineering Technology program, this section discusses implications for vocational institutions seeking to strengthen industry-education integration. The analysis suggests that deeper collaboration requires more than the construction of training facilities. It also depends on institutional mechanisms for curriculum development, enterprise participation, quality assurance, and shared understandings of talent cultivation goals. Therefore, the SZPU case provides potentially transferable insights for vocational institutions operating in technology-intensive regional economies.

Targeting high-end industrial demands and aligning with regional economic development

According to the Outline for Building China into an Educational Power (2024-2035), emphasis is placed on aligning talent cultivation with socio-economic development, requiring both anticipatory planning and dynamic program adjustment (Central Committee of the Communist Party of China & The State Council, 2025). Vocational education must be guided by market demand; however, low-end labor markets are often characterized by easy substitution and weak technological accumulation. By contrast, high-end industrial demands offer a sustainable direction for the advancement of vocational education.

Therefore, vocational colleges and universities should determine their own positioning according to regional cutting-edge industries and establish professional directions through regional adaptability and industrial relevance. Actively participating in local economic and industrial activities enables colleges and universities to combine enterprise tutors with academic teachers, classroom learning with workplace practice, and theoretical knowledge with practical experience. This two-subject educational model can improve the competitiveness of students and ensure that graduates' abilities better match enterprises' needs (Yu, 2018). When choosing enterprise partners, rather than just focusing on large enterprise brands, colleges and universities should prioritize cooperation with medium-sized high-tech enterprises with core technologies. These enterprises usually have faster technology iteration and stronger market sensitivity and can provide a more forward-looking and practical training environment. When cooperating with leading enterprises, institutions should comprehensively consider factors such as enterprise capacity, industrial development trajectory, supply chain positioning, and ecosystem compatibility to clarify common interests and establish a sustainable, mutually beneficial, and win-win school-enterprise cooperation model (Mei *et al*., 2024).

Reconstructing practice scenarios and deepening the educationalization of technology

In several developed economies, especially Germany, Austria, and Switzerland, dual vocational education and training (VET) combines school-based theoretical instruction with company-based practical training (Cedefop, 2020; Haasler, 2020; OECD Reviews of Vocational Education and Training, 2025). Research on work-integrated learning also suggests that productive vocational learning depends on connectivity between formal education, workplace participation, and reflection on practice (Guile & Griffiths, 2001; Stenström & Tynjälä, 2009). However, the transfer of the dual VET model depends on supportive institutional and industrial conditions, including strong employer participation, legal and regulatory frameworks, economic incentives, and effective intermediary organizations such as chambers or industry associations. Where these conditions are weak or unevenly distributed, implementing dual VET can be difficult (Hummelsheim & Baur, 2014).

SZPU sought to address this problem by developing a physical-layer collaboration model. Based on the fit between enterprise brand building and academic talent training, the school transforms the industrial production process into educational resources by establishing a micro-factory on campus. This model provides an experimental platform for technological upgrading while building a market-oriented paradigm for talent cultivation and realizing the optimal allocation of education and industrial resources.

Real enterprise research and development projects, such as optimizing iPhone backboard processing technology, are modularized and transformed into teaching cases, making technical bottlenecks part of the learning content. The design of the micro-factory follows two key teaching principles. First, the modular decomposition of knowledge points ensures the production line is divided into independent technical units corresponding to the theoretical content and certification standards. Second, the use of digital twin and augmented reality technology integrates virtual and physical components, simulates equipment operation, and reduces physical losses and hardware shortages in underdeveloped areas.

Ultimately, schools and enterprises jointly develop practice-oriented courses, produce comprehensive teaching materials, and promote synergy between learning, training, and work, so as to provide students with real industry experience (Liu & Yao, 2025).

Transforming traditional order-based training to promote adaptive talent development

The School of Artificial Intelligence at SZPU has successfully upgraded the traditional instructional training model to a more dynamic and market-responsive system by building a ternary ecosystem composed of an AI micro-training laboratory, a dual-track hierarchical teaching system, and a collaborative research platform. This transformation has three key characteristics.

First, it breaks technological closure and cultivates cross-industry, adaptive technical skills rather than narrow, enterprise-specific capabilities. Second, it reduces graduates' dependence on cooperative relationships with single enterprises, enhancing their employment flexibility and enabling them to maintain mobility and adaptability during industrial restructuring. Third, it emphasizes high-level cognitive ability and problem-solving ability and abandons standardized operation training, thereby enhancing graduates' creativity and innovativeness.

Building industry-education alliances to establish a dual-empowerment mechanism for collaborative education

The persistent disconnection between theory and practice in vocational education stems largely from the absence of a bidirectional empowerment mechanism linking schools and enterprises. In this context, sustainable development refers to maintaining long-term school-enterprise cooperation rather than relying on one-off equipment donations or short-term training projects. Partnerships between academia and industry therefore constitute the foundation of collaborative education when they support shared participation, mutual learning, and stable communities of practice (Que *et al*., 2025; Wenger, 1998). Ensuring sustained enterprise engagement requires a balance among corporate social responsibility, competitive advantage enhancement, and innovation-driven growth. This balance depends on incentive structures that motivate enterprise participation and ensure responsiveness to market demand. Such incentives may include tax preferences, equipment subsidies, shared intellectual-property arrangements, recognition of enterprise mentors, priority access to graduates, and opportunities to participate in applied R&D projects.

At the urban or regional level, industry-education alliances can reduce fragmentation by establishing a coordination platform for government agencies, vocational institutions, enterprises, and industry organizations. A leading institution can organize participating schools, enterprises, and local industry organizations. Shared training spaces and joint curriculum development can strengthen educational coordination, while applied research projects provide a route for converting enterprise problems into educational resources (Xu *et al*., 2023).

SZPU shows that the effectiveness of the government-school-enterprise collaborative education system depends on strong institutional guarantees such as policy guidance, equipment subsidies, tax incentives, joint investment mechanisms, curriculum development agreements and certification systems. Local governments can provide tax incentives and equipment subsidies, while schools and enterprises jointly invest in infrastructure construction, curriculum development, and certification systems. Rather than proving general effectiveness, the SZPU case indicates that such a framework can create conditions for reducing the gap between education supply and market demand and for coordinating the industrial, education, talent, and innovation chains. In high-tech fields such as AI, this method may provide a governance reference for vocational institutions seeking to coordinate enterprise participation, curriculum development, practical training, and quality assurance, but its broader effects require further empirical testing.

CONCLUSION

This case study examined how SZPU's Artificial Intelligence Engineering Technology program developed a three-tier model of industry-education integration. The findings suggest that effective collaboration in technology-intensive vocational education requires more than shared equipment or enterprise participation. It depends on the progressive connection of physical resources, institutional mechanisms, and cognitive alignment between schools and enterprises.

Theoretically, the three-tier model offers a layered framework for understanding how school-enterprise cooperation may deepen from resource sharing to institutional coordination and knowledge co-creation. Practically, the case highlights the value of micro-factory environments, curriculum-certificate integration, enterprise participation in teaching, and multi-stakeholder quality assurance. From a policy perspective, the case suggests that local governments can support sustainable collaboration through funding, tax incentives, certification systems, and coordination platforms.

Several limitations should be acknowledged. The analysis is based on a single institutional case and relies mainly on documents, program materials, cooperation records, and publicly available information. Therefore, the findings cannot be generalized without caution. Future research could compare multiple vocational institutions, collect interview or survey data from students, teachers, and enterprise mentors, and evaluate the long-term effects of the model on graduate employment, skill development, and enterprise innovation.

DECLARATIONS

Acknowledgments
None.

Author contributions
Yuan L: Investigation and Writing—Original draft. Wen T: Investigation and conceptualization. Lin DL: Investigation and Writing—Review and Editing. All authors have read and approved the final version.

Funding
This research was supported by Guangdong Provincial Philosophy and Social Sciences Planning Project 2024 "Foreign Language Special Project": "Construction of Digital Textbooks for Higher Vocational Foreign Languages under the Perspective of Smart Education—Taking the Development and Application of Digital Textbooks for Minor Languages as an Example" (No. GD24WZXY02-05); Guangdong Provincial Educational Science Planning Project (Higher Education Special Project) 2024: Regional Implementation Differences and Effect Evaluation of Guangdong Provincial Vocational Education Classification Enrollment Policy: A Multi-Dimensional Analysis (No. 2024GXJK767); Shenzhen Polytechnic 2023 School-level Supporting Project (Social Sciences): Research on Innovation of Vocational College Entrance Examination System in the Guangdong-Hong Kong-Macao Greater Bay Area (No. 6023310020S).

Ethical approval
Not applicable.

Informed consent
Not applicable.

Declaration of conflicting interests
The authors have no conflicts of interest to declare.

Generative AI use declaration
None.

Data availability statement
No additional data.

REFERENCES

Admissions Website-Shenzhen Polytechnic University. (2024). ntroduction to Programs in the School of Artificial Intelligence. Retrieved June 3, 2026, from https://zhaosheng.szpu.edu.cn/zyjs/rgznbkxy.htm

Akkerman, S. F., & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of Educational Research*, *81*(2), 132-169. https://doi.org/10.3102/0034654311404435

Billett, S. (2001). Learning through work: Workplace affordances and individual engagement. *Journal of Workplace Learning*, *13*(5), 209-214. https://doi.org/10.1108/eum0000000005548

Cedefop. (2020). Vocational education and training in Europe, 1995-2035: Scenarios for European vocational education and training in the 21st century. Publications Office of the European Union. Retrieved June 1, 2026, from https://www.cedefop.europa.eu/en/publications/3083

Central Committee of the Communist Party of China & The State Council. (2019, February 18). Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area. Retrieved June 2, 2026, from https://www.bayarea.gov.hk/filemanager/en/share/pdf/Outline_Development_Plan.pdf

Central Committee of the Communist Party of China & The State Council. (2025, January 19). [Outline for building China into an educational power (2024-2035)]. Retrieved June 2, 2026, from https://www.moe.gov.cn/jyb_xxgk/moe_1777/moe_1778/202501/t20250119_1176193.html

General Office of the State Council of the People's Republic of China. (2017, December 19). [Several opinions on deepening industry-education integration (Guobanfa [2017] No. 95)]. Retrieved June 3, 2026, from https://www.gov.cn/zhengce/content/2017-12/19/content_5248564.htm

Guile, D., & Griffiths, T. (2001). Learning through work experience. *Journal of Education and Work*, *14*(1), 113-131. https://doi.org/10.1080/13639080020028738

Haasler, S. R. (2020). The German system of vocational education and training: Challenges of gender, academisation and the integration of low-achieving youth. *Transfer: European Review of Labour and Research*, *26*(1), 57-71. https://doi.org/10.1177/1024258919898115

Han, R. (2024). [Analysis of the integration policy of industry and education in China's vocational education from the perspective of policy tools]. *Vocational Education*, *13*(6), 2425-2435. https://doi.org/10.12677/ve.2024.136372

Hummelsheim, S., & Baur, M. (2014). The German dual system of initial vocational education and training and its potential for transfer to Asia. *Prospects*, *44*(2), 279-296. https://doi.org/10.1007/s11125-014-9311-4

Liu, Y., & Yao, G. (2025). [A Study on the Diversified Development of Vocational Undergraduate Education and Application-oriented Undergraduate Education]. *Vocational Education Development and Research*, (1), 41-49. https://doi.org/10.19796/j.cnki.2096-6555.2025.01.006

Luo, Y. (2026, January 22). [SZPU: Continuously upgrading specialized industrial colleges to ensure students "learn what they will use"]. Minsheng Weekly. Retrieved June 3, 2026, from https://www.msweekly.com/mobile/show.html id=180820

Mei, X., Jiang, J., Li, W., Zhang, J., Wu, Q., Fang, F., & Zhang B. (2024). [Development model and practice of industry-education integration: Experience from Shenzhen Polytechnic University]. *Journal of Shenzhen Polytechnic University*, *23*(4), 23-31. https://doi.org/10.13899/j.cnki.szpuxb.2024.04.003

National Development and Reform Commission. (2021). [*Outline of the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035 of the People's Republic of China*]. National Development and Reform Commission.

OECD Reviews of Vocational Education and Training. (2010). *Learning for Jobs: OECD Reviews of Vocational Education and Training*. OECD Publishing. https://doi.org/10.1787/9789264087460-en

OECD Reviews of Vocational Education and Training. (2025). *Vocational Education and Training Systems in Nine Countries*. OECD Publishing. https://doi.org/10.1787/1a86eb6c-en

Our China Story. (2024, August 26). China's first batch of special economic zones approved for establishment. Retrieved June 3, 2026, from https://www.ourchinastory.com/en/12630/China%27s-first-batch-of-special-economic-zones-approved-for-establishment

Que, M., Zhu, Y., & Chen, C. (2025). [How to Construct a Vocational Education System Integrating Industry and Education: Insights from Industry-School Partnerships in Australia]. *Chinese Vocational and Technical Education*, (6), 50-60.

School of Artificial Intelligence-Shenzhen Polytechnic University. (2024). [School of Artificial Intelligence]. Shenzhen Polytechnic University. Retrieved June 3, 2026, from https://english.szpu.edu.cn/Faculties/Xili_Campus/School_of_Artificial_Intelligence.htm

Shenzhen Polytechnic University. (2019, July 30). [The "Tsinghua and Peking University" among vocational colleges]. Retrieved June 3, 2026, from https://www.sohu.com/a/330233028_115563

SmartMore Corporation Limited. (2023, December 15). [Exploring new paths of industry-education integration: Empowering talent training through intelligent manufacturing]. Retrieved June 3, 2026, from https://zhuanlan.zhihu.com/p/672358719

Stenström, M. L., & Tynjälä, P. (2009). *Towards integration of work and learning: Strategies for connectivity and transformation*. Springer Dordrecht. https://doi.org/10.1007/978-1-4020-8962-6

Wenger, E., (1998). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge University Press. https://doi.org/10.1017/CBO9780511803932

Xinhua. (2022, January 12). [China to further promote digital economy in 14th Five-Year Plan period]. Retrieved June 3, 2026, from https://english.www.gov.cn/policies/latestreleases/202201/12/content_WS61de9a35c6d09c94e48a385f.html

Xu, J. L., Li, L. L., & Bian, F. (2023). [Municipal scale, contingent value and main paths of municipal industry-education consortium construction—practices and thoughts of Shenzhen polytechnic university]. *Vocational and Technical Education*, *44*(29), 6-10.

Yang, C. (2023). Digital economy drives regional industrial structure upgrading: Empirical evidence from China's comprehensive big data pilot zone policy. *PLoS One*, *18*(12), e0295609. https://doi.org/10.1371/journal.pone.0295609

Yu, S. Y. (2018). [A Comparative Study on the Model of School-enterprise Collaborative Education in Vocational Colleges-Taking the Talent Training of the Ordered Class as an Example]. *Journal of Vocational Education*, (6), 138-141+147.

Zhang, Q., & Gu, Y. (2021). [Link and Cooperation:Internal Logic of the Organic Connection of"Four Chains"in the Integration of Industry and Education]. *Journal of National Academy of Education Administration*, (4), 48-56. https://doi.org/10.3969/j.issn.1672-4038.2021.04.008

Zhuang, X. (2018). [The internal contradictions and solutions of industry-education integration]. *China Higher Education Research*, (9), 81-86. https://doi.org/10.16298/j.cnki.1004-3667.2018.09.15