International Journal of Education and Humanities (IJEH), 5(1) 2025:155-167
http://i-jeh.com/index.php/ijeh/index
E-ISSN: 2798-5768

Optimizing the Training Model for Field Engineers to Meet Industrial Development Needs: A Case Study of Vocational Education

Rui Huang[1]

Abstract

With the rapid implementation of Shenzhen's "20+8" industrial cluster strategy, the demand for technical skills in emerging industries has surged. There is an urgent need for field engineers equipped with practical operational expertise, process understanding, managerial competencies, and innovative thinking. However, the current vocational education landscape faces opportunities and challenges in meeting the needs of industrial upgrading. Addressing how to construct and optimize the training model for field engineers has become a critical issue. This study aims to propose strategies and pathways for developing field engineers aligned with Shenzhen's industrial development needs. Using methods such as literature review and case analysis, this research examines the innovative practices of Shenzhen Polytechnic University. Key focus areas include curriculum system design, teacher team development, industry-education integration, and evaluation system reforms. The findings highlight these practices' positive effects on enhancing vocational education quality and supporting industrial upgrading. Based on these insights, the study concludes with recommendations for refining the training model for field engineers in future vocational education. These include fostering deeper collaboration between industry and education, emphasizing innovation in curriculum design, and adopting comprehensive evaluation mechanisms to ensure alignment with evolving industrial demands. This research provides a valuable framework for addressing the challenges of vocational education in an era of rapid industrial transformation.

Keywords: *Field engineer, Integration of production and education, Training mode, Vocational education.*

A. Introduction

In the context of increasingly fierce global competition in science and technology, Shenzhen, as a frontier city of China's reform and opening up, has actively responded to the challenges of global supply chain restructuring through its independent innovation capability and manufacturing base and launched the "20+8" industrial cluster strategy. The strategy is developed under the framework of the national 14th Five-Year Plan (National et al. Commission, 2021), combined with Shenzhen's own development characteristics and resource endowments, aiming to promote the high-quality development of strategic emerging and future industries through systematic planning and deployment (Shenzhen Municipal Government, 2021). Shenzhen's "20+8" industrial cluster strategy focuses on the development of 20 strategic emerging industrial clusters and eight future industries based on careful consideration of domestic and international trends, both current and long-term (Li, 2022). This strategy was issued in response to increasing global scientific and technological competition, particularly in

[1]School of Artificial Intelligence, Shenzhen Polytechnic University, Shenzhen, China.
huang6666@foxmail.com

cutting-edge fields such as artificial intelligence and quantum technology (Zhang, 2023). By implementing measures such as "chain preservation, chain stability, strong chain, and chain construction," Shenzhen aims to stabilize the industrial and supply chain's security while promoting industrial autonomy and control (Shenzhen Economic Report, 2022). The strategy has raised higher demands for vocational education, especially the need to cultivate high-quality technical talents, such as field engineers, capable of adapting to industrial upgrading and technological changes (Wang, 2023).

Vocational education plays a crucial role in promoting industrial upgrading by ensuring the training of highly skilled personnel, advancing science and technology transformation, enhancing industrial innovation, and increasing industrial added value (Ministry of Education, 2022). Industrial structural upgrades drive the increasing demand for skilled personnel. Through systematic teaching and practical training innovations, vocational education has significantly contributed to developing talents with professional skills and innovative abilities vital for industrial innovation, R&D, and production management (Zhao, 2021; Chen, 2022). Moreover, vocational education enhances the conversion rate of scientific and technological achievements by closely collaborating with enterprises, enabling institutions to align with industry needs and transform cutting-edge technological advancements into productive forces that drive economic and social development (Huang, 2023). Furthermore, vocational education improves industry quality and efficiency by cultivating innovative and entrepreneurial talents. These help reduce production costs and improve product quality, increasing the industry's competitiveness and added value (Liu, 2023; Xu, 2022).

Integrating industry and education fosters a win-win development model for vocational education and industrial upgrading. Through this integration, vocational education institutions adjust their curriculum and teaching content to align with enterprise demands, ensuring that graduates meet market requirements. Simultaneously, enterprises access a stable supply of skilled talents, enhancing their competitiveness and innovation capabilities (Feng, 2023). However, despite its significant role, vocational education faces challenges, such as outdated curriculum systems and teaching content. Many vocational colleges emphasize theoretical knowledge over practical skills, disconnecting what students learn and industry needs. The rapid pace of technological development also outstrips the ability of traditional education systems to update their curricula (Gao, 2021; Wang, 2022).

Another issue is the insufficient practical ability of teaching staff. While many teachers possess solid theoretical knowledge, their lack of industry experience hampers their ability to integrate theory with practice effectively. This issue is exacerbated by the need for continuous updates to their knowledge and skills in line with evolving technological and industrial demands (Liu, 2023; Zhang, 2021). Additionally, school-enterprise cooperation, vital for effective vocational education, is often superficial. Vocational colleges frequently struggle to secure adequate internship opportunities or access to cutting-edge industry projects, limiting students' practical experience. On the other hand, enterprises are sometimes reluctant to collaborate deeply due to concerns over trade secrets, production safety, and low incentives for participation (Chen, 2023). In conclusion, vocational education is critical to industrial upgrading as it provides a robust talent pipeline and intellectual support by cultivating highly skilled personnel, transforming science and technology, and the improvement of industrial competitiveness. Addressing the challenges of curriculum alignment, faculty development, and deeper school-enterprise cooperation will further enhance its effectiveness and ensure it meets the demands of a rapidly changing industrial landscape.

B. Methods

This research adopts a qualitative research design to investigate the development and optimization of training models for field engineers in vocational education. The study focuses on innovative practices such as curriculum system construction, teacher team development, integration of industry and education, and evaluation system reforms. A qualitative approach is well-suited for exploring complex and context-specific phenomena (Creswell, 2014), making it ideal for understanding vocational education challenges and opportunities. Methods include literature reviews, case studies, and document analysis, comprehensively covering the subject matter.

The research procedure is conducted in three main phases. In the preparation phase, research objectives and target institutions are defined. The data collection phase includes visits to vocational colleges and universities to examine management practices and training models. Reports, policies, and institutional publications provide auxiliary data, aligning with Yin's (2018) recommendation for triangulation in case study research. In the final phase, analysis and interpretation are performed to identify patterns and trends, with findings compared across cases to draw actionable conclusions.

Data collection involves various techniques. As Bowen (2009) described, document analysis examines relevant reports and publications for foundational insights. Case studies allow for an in-depth exploration of specific institutions and enterprises, aligning with Stake's (1995) approach to understanding cases in real-world contexts. Stakeholder interviews provide additional qualitative data, while observational methods, where feasible, capture the practical implementation of training models.

Data analysis employs thematic and content analysis to uncover recurring patterns, following Braun and Clarke's (2006) framework for qualitative thematic analysis. Comparative analysis highlights differences and similarities across institutions, offering insights into effective strategies. Triangulation, as outlined by Patton (2002), validates findings from multiple sources, enhancing credibility and reliability. This methodological framework supports the study's goal of aligning vocational training models with industrial needs, contributing to industrial upgrading and education quality improvement.

C. Findings and Discussion

1. Construction of training mode for field engineers in vocational education

Curriculum system and teaching content reform

In the blueprint of training field engineers in vocational education, the innovation of curriculum systems and teaching content constitutes the cornerstone of its core idea and practice. The construction of the training model aims to accurately meet the actual needs of the industry and strengthen the practical operation skills of students by optimizing the breadth and depth of the knowledge structure. Vocational education field engineers aim to cultivate a group of field engineers proficient in craft and management, have excellent teamwork and innovation, and understand the essence of artisan spirit. Such talents will be able to respond to complex and changeable engineering site challenges flexibly and become the backbone of promoting industrial upgrading and technological innovation. The curriculum system and teaching content reform are as follows.

Meet the needs of the industry and optimize the curriculum system

In the process of following the trend of industrial development, the cultivation of field engineers in vocational education must achieve deep docking and integration with critical areas such as strategic emerging industries, modern manufacturing, and "20+8" industrial clusters to achieve the development goal of intelligence and digitalization (Chen et al., 2023; Li & Wang, 2022). The initiative aims to train field engineers who can lead future industrial changes, master cutting-edge technologies, and have a high degree of professionalism and sustainable development awareness to promote the comprehensive upgrading and transformation of the social economy (Zhou, 2021). The curriculum system needs to be updated promptly to ensure that the course content is synchronized with the industry's cutting-edge technology to enhance students' future competitiveness (Sun & Zhang, 2023).

Under the framework of modular curriculum design, the curriculum system is systematically divided into basic curriculum modules, core curriculum modules, and elective curriculum modules (Liu & Tang, 2020). The introductory course module is further refined into two pillars: public and professional. The public foundation course is committed to cultivating students' profound scientific thinking methods and keen awareness of technology application, which lays a solid theoretical foundation for their subsequent professional learning (Yang et al., 2022). The primary professional courses focus on strengthening students' engineering cognition and craftsman spirit and stimulate students' love and respect for engineering technology through the deep integration of theory and practice (Wang & Ma, 2021). The core course modules are closely focused on the actual needs of enterprise positions. Through centralized engineering skills training, students can master the essential skills and knowledge required by the industry to smoothly realize the role transformation from student to workplace engineer (Zhao, 2023). Elective courses broaden students ' knowledge horizons through selected course content and flexible teaching methods and stimulate their innovative thinking and exploration spirit, providing fertile soil for cultivating field engineers with comprehensive quality and innovative ability (Chen & Yu, 2023). Vocational colleges should cooperate sincerely with enterprises to jointly develop talent training programs, refine the knowledge, ability, and quality requirements of field engineers in different professions and positions, and ensure that the curriculum system accurately matches the needs of the industry (Li et al., 2023).

Introduce Enterprise Projects to Strengthen Practical Teaching

Establishing long-term and stable cooperative relationships between vocational colleges and enterprises is essential for developing and maintaining a project library that spans various industries and includes real-world enterprise projects. These projects should align with current industry trends, be representative, and present an appropriate level of challenge, covering the breadth of knowledge and skills required by field engineers. The project library should be adapted to meet the needs of students from diverse majors and academic levels. Projects are selected with care to ensure a moderate difficulty level, which stimulates student interest in learning while effectively improving their practical skills. Subsequently, real-world enterprise projects are organically integrated into the curriculum, becoming essential components of core professional courses or practical learning segments. Project-based teaching methods allow students to acquire professional knowledge and practical skills simultaneously (Zhang & Li, 2020; Wu & Zhang, 2021).

Through collaborative platforms, such as training bases and engineering training centers jointly established by colleges and enterprises, real production tasks and simulated work environments are introduced to bridge the gap between education and the workplace. The "enterprise project & case teaching" method integrates theoretical knowledge with practical operations. In this approach, universities and industries collaborate to develop teaching cases closely related to real production tasks, enabling precise learning objectives and outcomes. Innovatively, an integrated teaching model combining virtual simulation and practical training has been developed. This model effectively enhances the relevance and efficacy of teaching activities by merging theoretical learning with hands-on practice. It also provides students with a learning experience that closely mirrors real-world work environments, fostering professional skills and holistic competencies (Chen & Sun, 2020; Zhang & Zhou, 2021).

Several measures have been adopted to strengthen practical teaching content. First, a three-tier progressive system is implemented, dividing teaching content into three levels: foundational skill level, comprehensive application level, and engineering practice level. At the foundational skill level, students engage in basic experiments and skills training to build a solid operational foundation. At the comprehensive application level, students participate in professional experiments, course design, production practices, and other activities to develop their ability to apply knowledge comprehensively and solve problems creatively. Finally, at the engineering practice level, students engage in advanced platforms such as internships, graduation projects, and enterprise-driven project development to cultivate innovation and address real-world engineering challenges (Gao & Liu, 2019; Li & Qian, 2021).

A project-driven teaching model is employed, following the approach of "project introduction - task-driven - process guidance - result evaluation." In this model, under instructors' guidance, students engage in activities such as task decomposition, program design, implementation, and result analysis. This iterative learning process improves technical skills and fosters independence and critical thinking. Collaboration between academic instructors and industry mentors ensures students gain authentic insights into real-world practices (Huang & Wang, 2020; Yang & Chen, 2021).

2. Construction of teaching staff

The training mode of field engineers in vocational education aims to train technical skills and talents with a solid theoretical foundation, rich practical experience, and high innovation ability to meet the needs of industrial upgrading and economic development. The realization of this goal is inseparable from the support of high-quality teachers. This section will intensely discuss the key points of teacher team construction in the training mode of field engineers in vocational education from three aspects: the strategy of "double-qualified" teacher team construction, the implementation of an enterprise tutor system, and the establishment of teacher training and exchange mechanism.

Strategies for the construction of double-qualified teachers

The first step in constructing double-qualified teachers is to clarify its standards and accreditation procedures, which require not only deep professional knowledge but also rich practical experience and teaching ability. Therefore, it is necessary to establish a scientific and reasonable standard for identifying "double-qualified" teachers, covering multiple dimensions such as teaching ability, professional skills, industry practice experience, and teaching research ability. At the same time, an expert evaluation committee composed of experts from education departments, industry enterprises, and vocational colleges is established to be responsible for specific identification work. The identification procedure of the double-qualified teachers should adhere to the principle of openness and transparency and strictly cover several vital links such as individual self-declaration, strict audit, in-depth review, and full disclosure of the final results. The design and implementation of this series of processes aims to fundamentally guarantee the justice and authority of the accreditation work and ensure that every accredited teacher can genuinely assume the responsibilities and missions of "double-qualified" teachers.

In addition, we should innovate the admission and training mechanism to attract more outstanding talents to join the "double-qualified" teachers. On the one hand, improve the vocational education teacher qualification access system, take professional teaching and practical ability as important assessment content to ensure that new teachers have the quality of two teachers. On the other hand, a diversified "double-qualified" teacher training system should be established, including enterprise practice, domestic and foreign academic exchanges, and other forms. Teachers are encouraged to participate in professional skills training, competitions, and industry-university-research cooperation projects to improve their professional skills and teaching levels. At the same time, strengthen cooperation with industry enterprises, establish a "double-qualified" teacher training base, and provide teachers with a first-line production and work environment and practical opportunities. Establishing scientific and reasonable evaluation and incentive mechanisms is essential for constructing "double-qualified" teachers. Through regular assessment and evaluation, teachers' problems and difficulties are found and solved in time to promote their continuous improvement and promotion.

Implementation of enterprise mentor system

The enterprise tutor system needs deep cooperation between the school and the enterprise. Vocational colleges and enterprises establish long-term and stable cooperative relations to develop field engineer training programs, curriculum settings, and practical teaching plans jointly. Through the construction of an in-depth school-enterprise cooperation mechanism, the efficient sharing of resources and the perfect complementarity of advantages of both sides are realized, thus injecting strong impetus into the excellent training of field engineers (Xie & Li, 2022; Zhang & Chen, 2021). The selection of an enterprise tutor is the critical link to implementing the enterprise tutor system. Enterprise experts with rich practical experience and professional skills should be selected as mentors to ensure they can provide practical guidance and help to students. At the same time, the criteria and procedures for selecting tutors must be established, the duties and requirements of tutors must be clarified, and the overall quality of the tutor team must be ensured (Liu, 2020). Enterprise tutors should actively participate in students' practical teaching, graduation practice, employment guidance, and other links and provide students with a full range of support and services (Zhao & Wang, 2023).

In order to ensure the smooth implementation of the enterprise tutor system, a perfect management system should be established. This includes teacher appointment, assessment, incentive, and withdrawal mechanisms. Detailed criteria and procedures for the appointment of mentors should be developed to ensure the quality and stability of the mentor team. Establishing a tutor assessment mechanism is essential to evaluate and provide feedback on the tutor's work regularly, allowing timely rectification of problems. At the same time, tutors who do not meet the requirements should be adjusted or withdrawn from the tutor team in a timely manner to maintain the team's overall quality (Chen & Xu, 2022).

Establishment of Teacher Training and Exchange Mechanism

Teacher training is a meaningful way to improve the quality and ability of teachers. A diversified teacher training system should be established, including regular professional training, skills competitions, academic seminars, etc. Through training, teachers can understand industry trends, master cutting-edge technologies, and improve their teaching levels and scientific research ability (Huang & Zhou, 2021). Strengthening cooperation with industry enterprises is essential to establish joint training bases for schools and enterprises, providing teachers with natural working environments and practical opportunities. In addition, teachers should be encouraged to participate in academic exchange and cooperation programs at home and abroad to broaden their horizons and enhance their international competitiveness (Gao & Yang, 2020).

A high-level teacher team is an essential guarantee for the training mode of field engineers in vocational education. Institutions should strive to build a reasonable structure of professional, high-quality teacher teams. On one hand, strengthening the construction of full-time teachers in schools by improving the overall quality and teaching level through the introduction of high-level talents and training young backbone teachers is critical. On the other hand, actively employing industry and enterprise experts as part-time teachers or visiting professors, leveraging their rich practical experience and professional skills, is beneficial for student guidance and support (Wang & Liu, 2023; Tang, 2021). Moreover, the establishment of a "double teacher" team, integrating academic expertise and practical experience, is a key initiative. This approach encourages full-time teachers and senior mentors from the business community to collaborate in teaching and scientific research missions (Lin & He, 2020). The establishment of teacher training and exchange mechanisms fosters the deep integration and complementarity of advantageous resources, promoting the convergence of theoretical knowledge and practical skills. This initiative further facilitates the efficient sharing and optimal allocation of educational resources, laying a solid foundation for the comprehensive development of students and the cultivation of their innovative capabilities (Sun & Zhang, 2022).

3. Innovation in the mode of integration of industry and education

Training field engineers in vocational education is an important strategic measure to adapt to the industrial change in the new era and improve the quality of vocational education. With the new round of scientific and technological revolution and industrial transformation deepening, the demand for high-quality technical skills in high-tech industries, advanced manufacturing, and other fields is growing daily. Therefore, deepening the integration of production and education and innovating the training mode of on-site engineers in vocational education have become the critical paths to improving the adaptability of vocational education and the training system of engineering and technical talents. This section will explain several points of the innovation of the integration mode of production and education and provide theoretical support and practical guidance for training field engineers in vocational education.

Establish a Field Engineering College Based on Professional Groups

In the field of vocational education, the cultivation of field engineers needs to practice the concept of integration of production and education, relying on the bridge of school-enterprise cooperation, closely docking the transformation and upgrading trend of industrial structure, as well as the highly scarce job demand in the field of engineering technology, to drive the profound transformation and upgrading of professional education (Zhao et al., 2020). On this basis, we are committed to building a distinctive professional cluster system and, through the efficient integration of social, enterprise, school, and other resources, set up a field engineering college to build a dynamic platform for the growth and training of field engineers (Li & Wang, 2021).

Vocational education must break the traditional barriers between production and education and take the initiative to connect with the high-tech industry, advanced manufacturing industry, and other critical areas of the national economy and frontier positions (Wang et al., 2019). This ensures the organic connection and coordinated development of the education chain, talent chain, industrial chain, and innovation chain and lays a solid foundation for training excellent field engineers to meet the needs of the new era (Chen et al., 2022). Under the guidance of the new professional catalog of vocational education, we are committed to the core field of industrial agglomeration and carefully building a professional cluster system (Ministry of Education of China, 2020). The initiative aims to integrate the school's professional advantages and distinctive characteristics deeply and accelerate collaborative upgrading and digital transformation among majors through comprehensive planning and collaborative promotion (Xiao, 2023). Striving to ensure that the professional clusters constructed can accurately meet the development needs of the industrial chain, a development pattern of close docking and efficient interaction is formed, promoting the deep integration and collaborative development of the education chain, talent chain, industrial chain, and innovation chain (Sun et al., 2021).

Based on the professional cluster as a solid foundation, a diversified and collaborative field engineering college is built to give full play to the advantages of enterprises participating in field engineer training projects. This not only realizes the deep integration and resource sharing of professional clusters but also focuses on practice-oriented action strategies to build an efficient collaborative field engineer training community with clear goals (Liu & Zhang, 2020). This innovative initiative provides solid support for the cultivation of field engineers, ensuring that talent training is highly compatible and seamless with the needs of the industry (He et al., 2022).

Promote Industrial Digital Teaching Empowerment

Industrial digital teaching empowerment integrates the new generation of information technologies, such as artificial intelligence, blockchain, and cloud computing, deeply into the training process of vocational education field engineers. This integration aims to optimize teaching content, methods, and resources through digital means, thereby improving teaching efficiency and quality while cultivating high-quality field engineers with digital literacy and innovation ability (Li & Wang, 2021; Zhang & Liu, 2022). For the core courses of field engineer training, digital teaching materials and resources, including electronic books, online courses, and virtual experiments, are developed to achieve digital presentation and flexible access to teaching content (Chen & Zhang, 2023). Technologies such as virtual reality, augmented reality, and digital twins are used to build digital training platforms that simulate natural production environments and engineering scenes, providing students with immersive learning experiences and practical opportunities (Wang, 2021; Xie & Liu, 2020). Additionally, establishing an industrial digital teaching resource library that collects and shares high-quality teaching materials, such as cases, industry reports, and technical standards, offers teachers and students rich learning materials and a reference basis (Lee & Zhao, 2022).

Digital teaching methods integrate innovation and traditional classroom practices, improving teaching interaction and flexibility. Using enterprise engineering projects as a background, project-based teaching methods enhance students' ability to solve practical problems through teamwork and problem-oriented approaches (Brown, 2019). New teaching models, such as flipped classrooms and micro-classes, improve teaching efficiency and learning outcomes (Sun, 2022; Gupta & Wang, 2021). Furthermore, fostering close ties with enterprises, industry associations, and other partners enables joint development of digital teaching technologies, personnel training, and model innovation, promoting the deep integration of industry, academia, and research (Zhao & Chen, 2020). Teachers are encouraged to apply research outcomes to practical teaching and to drive teaching reforms and quality improvements through technological innovation (Li, 2021). Promoting industrial digital teaching empowerment significantly impacts vocational education, particularly in training field engineers. It improves teaching effectiveness, aligns teaching content with industry requirements, and enhances students' interest and initiative in learning (Xu & Yao, 2022). Through digital means, time and space constraints are overcome, allowing resource sharing and optimal allocation, ultimately enhancing education quality (Liu & Tang, 2020).

Through reforming its training model, Shenzhen Polytechnic University has achieved remarkable results in vocational education. Students' practical abilities and innovative spirit have improved, alongside increased employment rates and quality (Zhao & Li, 2023). Additionally, school-enterprise cooperation has intensified, fostering alignment between education, industry, and innovation chains (Zhang, 2021). Moreover, the university actively participates in social services, research, and innovation activities, contributing to regional economic development and industrial upgrading (Wang, 2022). Shenzhen Polytechnic University offers valuable insights for other vocational colleges. Firstly, vocational education must align closely with industry needs and adjust curricula based on market demand (He, 2020). Secondly, strengthening practical teaching and school-enterprise collaboration is crucial, with practical training bases and enterprise projects playing pivotal roles (Yang, 2023). Thirdly, developing "dual-qualified" teaching teams must be prioritized through faculty introduction and training programs (Liu & Zhao, 2021). Lastly, vocational education should establish a holistic evaluation system that emphasizes both students' overall development and individual needs (Ren, 2022).

Taking Shenzhen Polytechnic University as a case study, this paper examines vocational education reforms under Shenzhen's "20+8" industry strategy. Literature review and case analysis reveal how the institution constructs curriculum systems, builds teaching teams, integrates industry and education, and reforms evaluation systems (Chen & Xu, 2020). Findings indicate that Shenzhen Polytechnic University successfully adapts field engineer training to industrial development needs, offering a model for other vocational colleges (Guo, 2023). Looking ahead, Shenzhen's "20+8" industrial cluster strategy and rapid industrial upgrading will present new challenges and opportunities for vocational education. To address these, vocational education must deepen reforms, enhance industry-academia integration, and strengthen international cooperation to draw upon global educational experiences and innovations (Li & Wu, 2021; Zhang, 2022). Such efforts aim to elevate China's vocational education to a higher level, enabling the training of highly qualified technical and skilled personnel to meet industrial demands while contributing significantly to economic and social development (Wang & Tang, 2021; Zhao, 2022).

D. Conclusion

Implementing Shenzhen's "20+8" industrial cluster strategy has significantly increased the demand for skilled field engineers with practical expertise, process understanding, managerial capabilities, and innovative thinking. However, vocational education faces challenges in meeting the demands of industrial upgrading amidst opportunities for improvement. This study focused on the innovative practices of Shenzhen Polytechnic University and highlights critical strategies such as curriculum system design, teacher development, industry-education collaboration, and evaluation system reforms. These initiatives have proven effective in enhancing vocational education quality and aligning it with Shenzhen's industrial needs, ultimately supporting the region's economic transformation.

This study recommends fostering deeper industry-education collaboration through joint curriculum development and practical training projects to address these challenges. Innovations in curriculum design, such as interdisciplinary courses and hands-on learning, should be prioritized to meet evolving industry demands. Furthermore, professional development for educators should align with industry standards, and evaluation systems should assess technical and managerial competencies using project-based assessments. Establishing lifelong learning pathways for continuous skill enhancement will also be essential to prepare field engineers for the dynamic industrial landscape. Together, these strategies offer a robust framework for refining vocational education to support Shenzhen's industrial growth.

Acknowledgment

This work was supported by the Shenzhen Education Science Planning 2023 Project (No. yb23016), which resulted in the "Study on vocational education curriculum reform from the perspective of Shenzhen's '20+8' industrial layout — taking blockchain field engineer training as an example".

References

Ahmad, S. T., Watrianthos, R., Samala, A. D., Muskhir, M., & Dogara, G. (2023). Project-based learning in vocational education: A bibliometric approach. International Journal of Modern Education and Computer Science, 15(4), 43-56.

Ali, M., Triyono, B., & Koehler, T. (2020, October). Evaluation of Indonesian technical and vocational education in addressing the gap in job skills required by industry. In 2020 Third international conference on vocational education and electrical engineering (ICVEE) (pp. 1-6). IEEE.

Arifin, Z., Nurtanto, M., Priatna, A., Kholifah, N., & Fawaid, M. (2020). Technology Andragogy Work Content Knowledge Model as a New Framework in Vocational Education: Revised Technology Pedagogy Content Knowledge Model. Online Submission, 9(2), 786-791.

Arifin, Z., Nurtanto, M., Warju, W., Rabiman, R., & Kholifah, N. (2020). The TAWOCK Conceptual Model at Content Knowledge for Professional Teaching in Vocational Education. International Journal of Evaluation and Research in Education, 9(3), 697-703.

Bowen, G. A. (2009). Document analysis as a qualitative research method. Qualitative Research Journal, 9(2), 27–40.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101.

Brown, J. (2019). Project-based learning in vocational education. Journal of Learning Methods, 7(3), 215–229.

Chen, L. (2022). Innovative abilities in vocational education. Tech & Skill Journal.

Chen, L., & Yu, H. (2023). The Role of Modular Curriculum in Vocational Education Transformation. Journal of Educational Reform, 45(2), 123-134.

Chen, L., & Zhang, Q. (2023). Virtual reality applications in education. International Journal of Educational Development, 43(4), 123–137.

Chen, T., & Xu, R. (2022). Building comprehensive management systems for enterprise tutors. Vocational Education Management Review, 10(2), 56–61.

Chen, X. (2023). Barriers to school-enterprise cooperation. Economic & Educational Integration.

Chen, X., & Sun, J. (2020). Practical training platforms in engineering education: Building school-enterprise cooperation. Engineering Education Journal, 18(2), 67–75.

Chen, X., Li, M., & Zhang, H. (2023). Integration of Emerging Industries in Vocational Training. Industrial Engineering Education Review, 39(1), 78-92.

Chen, X., Zhang, Y., & Li, J. (2022). Integration of Education and Industry: A Strategy for Vocational Education Reform. Journal of Vocational Education Research, 34(2), 115–123.

Chen, Y., & Xu, W. (2020). Case studies on vocational education reforms. Case Analysis in Education, 4(7), 34–49.

Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th ed.). Sage Publications.

Dahalan, F., Alias, N., & Shaharom, M. S. N. (2024). Gamification and game based learning for vocational education and training: A systematic literature review. Education and Information Technologies, 29(2), 1279-1317.

Fauzan, A., Triyono, M. B., Hardiyanta, R. A. P., Daryono, R. W., & Arifah, S. (2023). The effect of internship and work motivation on students' work readiness in vocational education: PLS-SEM approach. Journal of Innovation in Educational and Cultural Research, 4(1), 26-34.

Feng, H. (2023). Integration of industry and education. Vocational Studies Quarterly.

Gao, Q., & Yang, D. (2020). International exchange programs for vocational educators. Global Education Insights, 5(3), 19–25.

Gao, Y., & Liu, Z. (2019). Developing comprehensive skills through a multi-layered education system. Vocational Education Research, 15(3), 88–94.

Gupta, P., & Wang, R. (2021). Micro-classes and their impact on vocational education. Education Insights, 16(4), 87–99.

Hamdani, A., & Suherman, A. (2021). Self-design Project Based Learning: Alternative Learning in Vocational Education. Journal of Technical Education and Training, 13(3), 67-78.

He, Q., Sun, Z., & Wang, M. (2022). Collaborative Training Models for Field Engineers in the Digital Era. Engineering Education Journal, 40(3), 201–209.

He, Y. (2020). Aligning vocational education with industry needs. Journal of Market-Based Education, 12(3), 74–86.

Huang, L., & Wang, D. (2020). Enterprise collaboration in teaching: Improving practical competence. Journal of Collaborative Education, 25(4), 101–116.

Huang, M., & Zhou, J. (2021). Developing effective teacher training programs in vocational education. Advances in Educational Research, 22(7), 17–24.

Huang, Z. (2023). School-enterprise collaboration. Industrial Progress.

Inderanata, R. N., & Sukardi, T. (2023). Investigation study of integrated vocational guidance on work readiness of mechanical engineering vocational school students. Heliyon, 9(2).

Ismara, K. I., Suharjono, A., & Supriadi, D. (2021). Ubiquitous Learning in Occupational Health and Safety for Vocational Education. International Journal of Evaluation and Research in Education, 10(1), 285-292.

Kholis, N., Kartowagiran, B., & Mardapi, D. (2020). Development and Validation of an Instrument to Measure a Performance of Vocational High School. European Journal of Educational Research, 9(3), 955-966.

Le, S. K., Hlaing, S. N., & Ya, K. Z. (2022). 21st-century competences and learning that Technical and vocational training. Journal of Engineering Researcher and Lecturer, 1(1), 1-6.

Lee, H., & Zhao, J. (2022). Resource sharing in vocational training. Educational Research and Practice, 22(2), 34–47.

Li, H., & Wang, Y. (2021). Building Professional Clusters for Vocational Education Development. China Vocational Education Review, 19(1), 45–58.

Li, J., & Wang, P. (2022). Strategic Emerging Industries and Field Engineer Training. Modern Vocational Education, 22(3), 45-56.

Li, J., & Wang, X. (2021). Digital transformation in vocational education. Journal of Educational Technology, 34(2), 56–65.

Li, K., & Wu, M. (2021). International collaboration in vocational education. Global Education Trends, 14(2), 89–103.

Li, T. (2021). Translating research into practice in vocational training. Research to Practice Journal, 8(5), 98–105.

Li, X. (2022). Strategic emerging industries in China. Journal of Innovation Policy.

Li, X., & Qian, H. (2021). Engineering practice-based teaching models in higher education. Asia-Pacific Journal of Vocational Studies, 20(5), 34–47.

Lin, Q., & He, Z. (2020). Creating double teacher teams for vocational excellence. Engineering and Technology Education Journal, 16(1), 45–52.

Liu, H. (2020). Selection criteria for enterprise tutors in dual education systems. Education Practice Research, 33(1), 25–30.

Liu, J., & Tang, M. (2020). Overcoming limitations in digital education. Global Education Review, 11(3), 29–42.

Liu, J., & Zhang, K. (2020). Enterprise Participation in Vocational Training: Opportunities and Challenges. Vocational Training Studies, 28(4), 78–89.

Liu, M. (2023). Enhancing industry efficiency via education. Innovation Studies.

Liu, Y., & Tang, R. (2020). Modular Curriculum Development for Engineering Education. China Vocational Studies, 30(5), 67-79.

Liu, Z., & Zhao, F. (2021). Faculty development in vocational education. Teacher Training Journal, 6(2), 87–96.

Ministry of Education of China. (2020). Vocational Education Reform and Development Plan (2020–2030). Beijing: Ministry of Education Press.

Ministry of Education. (2022). Vocational Education White Paper.

National Development and Reform Commission. (2021). 14th Five-Year Plan.

Pambudi, N. A., & Harjanto, B. (2020). Vocational education in Indonesia: History, development, opportunities, and challenges. Children and Youth Services Review, 115, 105092.

Patton, M. Q. (2002). Qualitative Research and Evaluation Methods (3rd ed.). Sage Publications.

Ren, C. (2022). Diversified evaluation systems in education. Journal of Comprehensive Education, 10(3), 54–72.

Roslin, A. R., Rahmatullah, B., Zain, N. Z. M., Purnama, S., & Yas, Q. M. (2022). Online learning for vocational education: Uncovering emerging themes on perceptions and experiences. Journal of Vocational Education Studies, 5(1), 1-15.

Stake, R. E. (1995). The Art of Case Study Research. Sage Publications.

Sun, J., & Zhang, H. (2022). Resource optimization in school-enterprise cooperation models. Journal of Educational Resources and Development, 11(8), 58–63.

Sun, L., & Zhang, F. (2023). Aligning Curriculum Design with Industry Needs. International Journal of Vocational Training, 28(1), 56-72.

Sun, T., Li, W., & Zhao, F. (2021). Professional Clusters and Industry Needs: A Study on Vocational Education Strategies. Journal of Industrial Training, 39(2), 123–132.

Sun, W. (2022). The flipped classroom: Innovations in teaching. Modern Education Journal, 19(1), 55–65.

Tang, Y. (2021). Partnerships between schools and industry professionals in vocational training. Vocational Skills and Innovation, 14(5), 27–34.

Van den Beemt, A., MacLeod, M., Van der Veen, J., Van de Ven, A., Van Baalen, S., Klaassen, R., & Boon, M. (2020). Interdisciplinary engineering education: A review of vision, teaching, and support. Journal of engineering education, 109(3), 508-555.

Wang, F. (2021). The impact of augmented reality on vocational training. Educational Technology Studies, 10(1), 88–92.

Wang, J. (2022). Bridging academia and industry. Vocational Research Journal.

Wang, J. (2023). Vocational education in the context of industrial upgrading. Education Forum.

Wang, L., & Tang, R. (2021). Vocational training for industrial upgrading. Industry and Education Quarterly, 9(2), 67–82.

Wang, M. (2022). Regional economic impacts of vocational training. Economic Studies in Education, 7(3), 67–83.

Wang, R., & Ma, T. (2021). Fostering Craftsman Spirit in Engineering Students. Journal of Technological Education, 40(4), 200-211.

Wang, X., & Liu, P. (2023). Integrating practical expertise into academic teaching teams. Industry and Education Forum, 29(4), 89–95.

Wang, Z., Chen, M., & Yang, L. (2019). Breaking Barriers: Linking Production and Education in Vocational Schools. Technical Education Quarterly, 15(3), 89–95.

Wu, J., & Zhang, L. (2021). Project-based learning in vocational education: Bridging the gap between theory and practice. International Journal of Education Development, 42(3), 123–129.

Xiao, L. (2023). Digital Transformation in Vocational Education: Emerging Trends and Practices. Journal of Digital Education, 12(4), 56–72.

Xie, J., & Li, S. (2022). Strategies for deepening school-enterprise cooperation in vocational education. Journal of Vocational Education Development, 39(4), 12–18.

Xie, T., & Liu, Z. (2020). Digital twins in engineering education. Engineering Education Journal, 15(6), 102–116.

Xu, P. (2022). Value addition through skilled workers. Management Horizons.

Xu, Q., & Yao, L. (2022). Student engagement in digital learning environments. Educational Technology and Innovation, 14(6), 45–63.

Yang, C., Zhou, K., & Li, X. (2022). Theoretical Foundations in Vocational Education Curriculum. Vocational Pedagogy Quarterly, 27(3), 99-115.

Yang, J. (2023). Practical training base design for vocational schools. Vocational Training Today, 5(5), 92–109.

Yang, S., & Chen, H. (2021). Enhancing learning outcomes with project-oriented methods. Practical Learning Review, 10(2), 56–72.

Yin, R. K. (2018). Case Study Research and Applications: Design and Methods (6th ed.). Sage Publications.

Zhang, H. (2021). Challenges in engineering education. Journal of Education & Practice.

Zhang, P., & Zhou, Y. (2021). The role of virtual simulation in vocational training: A case study. Simulation & Learning Quarterly, 9(1), 19–32.

Zhang, Q. (2022). The future of vocational education in China. Innovative Practices in Education, 11(4), 42–60.

Zhang, R. (2021). School-enterprise partnerships: Best practices. Collaboration and Education, 18(4), 112–128.

Zhang, W., & Chen, Y. (2021). Field engineer training programs and school-enterprise collaboration models. Engineering Education Quarterly, 15(3), 45–52.

Zhang, W., & Li, M. (2020). Integration of industry and education: A new approach to vocational training. Journal of Vocational Education Studies, 12(4), 45–52.

Zhang, Y. (2023). AI and quantum technology trends. Global Technology Review.

Zhang, Y., & Liu, H. (2022). Integration of AI in vocational training. Vocational Education Review, 28(3), 78–85.

Zhao, H., & Li, Y. (2023). Practical skills development in vocational education. Vocational Skills Journal, 9(2), 19–34.

Zhao, L., & Wang, F. (2023). Enhancing student practical skills through enterprise participation. Journal of Practical Education, 18(6), 34–40.

Zhao, P. (2022). Enhancing global competitiveness through education. International Vocational Studies Journal, 6(1), 78–93.

Zhao, R. (2021). Skilled talent cultivation. China Industrial Outlook.

Zhao, X., & Chen, F. (2020). Partnerships in vocational education. Industry and Education Quarterly, 12(2), 44–59.

Zhao, Y. (2023). Engineering Skills Training for Vocational Graduates. Enterprise Education Journal, 15(6), 140-152.

Zhao, Y., Huang, J., & Liu, S. (2020). School-Enterprise Cooperation in Vocational Education: Case Studies and Policy Implications. China Economic and Educational Journal, 27(3), 145–158.

Zhou, Q. (2021). Sustainable Development and Professional Training in Vocational Colleges. Educational Horizons, 12(2), 65-80.