International Journal of Social Science, Education and Humanities
ISSN Print: 3104-4239
ISSN Online: 3104-4247
CD ISSN: 3104-4255
https://doi.org/10.63313/IJSSEH.9015

Research on the Innovation of School-Enterprise Collaborative Talent Cultivation Model for Electronic Major in Technical Schools and Dongying Petroleum Equipment Enterprises

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How to cite this paper: Guo, S. H. (2025). Research on the Innovation of School-Enterprise Collaborative Talent Cultivation Model for Electronic Major in Technical Schools and Dongying Petroleum Equipment Enterprises. International Journal of Social Science, Education and Humanities, 1(2), 36–44. ISSN Print: 3104-4239; ISSN Online: 3104-4247.
https://doi.org/10.63313/IJSSEH.9015
Published: 2025-10-22

Abstract

As a national key base for petroleum equipment manufacturing, Dongying has an industrial scale accounting for more than one-fifth of the national total and half of Shandong Province. As early as 2012, it achieved a total industrial output value of 50 billion yuan, with the production capacity of leading products such as land petroleum drilling rigs and pumping units ranking among the top in China, and its exports covering more than 60 countries and regions. However, it currently faces structural contradictions, including core technologies being constrained by others and a shortage of high-skilled talents in electronic fields. At the same time, the electronic major in local technical schools has problems such as disconnection between courses and industrial needs, mismatch between practical training and post standards, and a single evaluation system. Although preliminary cooperation has been promoted under the policy of integrating oil fields, local government and schools, a deep collaborative mechanism has not yet been formed. Based on the theoretical and practical experience of 7 core documents, this paper constructs a school-enterprise collaborative talent cultivation model of "industrial demand orientation—curriculum system reconstruction—practical training platform co-construction—closed-loop multi-evaluation". Through paths such as the integration of theory and practice, OBE (Outcome-Based Education) concept design, and optimization of Emerging Engineering experiment projects, it realizes the accurate connection between talent cultivation and industrial needs. The research shows that this model can effectively shorten the students' post adaptation cycle and improve the acquisition rate of vocational skill level certificates, providing two-way support for the transformation and upgrading of Dongying's petroleum equipment industry and the improvement of talent cultivation quality in technical schools.

Keywords

Dongying Petroleum Equipment; Electronic Major in Technical Schools;

School-Enterprise Collaborative Talent Cultivation; Integration of Theory and Practice; OBE Concept; Emerging Engineering Experiment

1. Introduction

As the birthplace and main oil-gas production area of Shengli Oilfield, Dongying District has formed a large-scale petroleum equipment manufacturing industry relying on oilfield development. By 2012, there were more than 1,200 enterprises engaged in petroleum equipment-related businesses, including 49 large-scale enterprises, with a total industrial output value of 50 billion yuan. Its products cover 37 series and more than 1,500 varieties in exploration, drilling, oil production, and gathering and transportation. The production capacity of leading products such as land petroleum drilling rigs and pumping units ranks among the top in China, with its industrial scale accounting for more than one-fifth of the national total and half of Shandong Province, making it a "leader" in the domestic industry [1]. With the global energy exploration expanding to deep-sea and unconventional oil-gas fields, Dongying's petroleum equipment enterprises have an increasingly urgent demand for electronic professionals with composite skills in intelligent control, embedded programming, and equipment fault diagnosis. However, enterprises generally report that existing skilled talents have problems of "technical mismatch, unskilled practice, and insufficient innovation". The core technologies being constrained by others and the shortage of high-skilled talents have become key bottlenecks restricting industrial upgrading [1].

Against this background, the CPC Dongying Municipal Committee and Dongying Municipal Government attach great importance to the integrated development of oil fields, local government and schools, and put forward the policy orientation of "industry co-cultivation and technology sharing". In 2023, they further promoted the joint efforts of oil fields and local government to boost high-quality industrial development, building a school-enterprise cooperation platform through mechanisms such as the "chain leader system" and "chain integration and consolidation meeting". Shengji Company and Sinopec Siji Factory jointly established an oil-gas equipment joint industrial base, and leading enterprises such as Kerui Group have also started cooperation with local technical schools [2] .However, most of the existing cooperation remains at the level of short-term internships and simple order-based training. Enterprises lack initiative in participating in talent cultivation, and the curriculum design and practical training programs are still dominated by technical schools unilaterally, failing to fully align with the dynamic needs of petroleum equipment posts. There is a "disconnection phenomenon" between the talent cultivation process and industrial needs [2].

From the supply side of the electronic major in technical schools, the traditional teaching model can hardly meet the needs of industrial development: the curricu-

lum system focuses on traditional electrical and electronic knowledge, with insufficient coverage of industry-specific content such as the principle of special electronic equipment for petroleum equipment and the anti-interference design of electronic equipment in oil-gas environments; the practical training mainly relies on general-purpose electronic experimental boxes, lacking special equipment such as drilling simulation control systems and oil production wellhead monitoring terminals, making it difficult for students to access real post scenarios; most teachers lack project experience in petroleum equipment enterprises, making it difficult to effectively guide targeted practical training; the evaluation system still focuses on theoretical exams (accounting for 60%) and basic skill assessments (accounting for 40%), failing to integrate corporate practical assessments, vocational skill level certificates (e.g., intermediate certificate for electronic equipment maintenance), and industry skill competitions, which cannot fully reflect students' post adaptability [4][5]. Based on this, this paper explores a new collaborative talent cultivation model between Dongying's petroleum equipment enterprises and the electronic major in technical schools, combining the theoretical and practical experience of 7 core documents, aiming to solve the dual dilemmas of industrial talent shortage and insufficient educational supply.

2. Current Situation and Problems of School-Enterprise Collaborative Talent Cultivation for Electronic Major in Technical Schools and Dongying Petroleum Equipment Enterprises

2.1. Current Situation of Collaborative Talent Cultivation

The electronic-related posts in Dongying's petroleum equipment enterprises mainly focus on intelligent control of drilling equipment, electronic monitoring of oil production equipment, and debugging of oil-gas gathering and transportation systems, requiring talents to have composite abilities in "circuit design + embedded programming + equipment fault diagnosis + API industry standard cognition" [1]. To meet this demand, the Dongying Municipal Government issued Opinions on Further Accelerating the Development of High-End Petroleum Equipment Manufacturing Industry, establishing a 500 million yuan special fund for industrial development to promote the integrated development of oil fields, local government and schools. The integration office of oil fields, local government and schools has established an industrial alliance by integrating enterprises and institutions, providing policy guarantees and platform support for school-enterprise collaborative talent cultivation [1][2]. The electronic major in local technical schools has opened core courses such as Electrical and Electronic Technology and Single-Chip Microcomputer Application, but the curriculum content is updated slowly, and most practical training equipment are general-purpose experimental boxes from five years ago, which have a generational gap with the production equipment of enterprises [4]. Some technical schools have attempted to cooperate with petroleum equipment enterprises, such as ar-

ranging students to participate in the assembly internship of electronic components in Shengji Company. However, the internship content is mostly simple operations, making it difficult for students to access core technical links. The proportion of enterprise technical backbones participating in teaching is less than 10%, resulting in limited effects of collaborative talent cultivation [5].

2.2. Analysis of Core Problems

First, the collaborative mechanism is incomplete. There is a lack of regular school-enterprise communication mechanisms. The professional construction committees mostly exist in form only, and enterprises have insufficient depth in participating in curriculum design and practical training program formulation. A long-term cooperation mechanism of "interest sharing and risk sharing" has not yet been formed [2]. As Zeng Yulin (2025) pointed out, some school-enterprise cooperation only stays on the surface, and enterprises lack enthusiasm for participation due to the absence of incentive policies, while technical schools also struggle to obtain real post demand data from enterprises [5]. Second, curricula are disconnected from industrial needs. The electronic major in technical schools still focuses on confirmatory experiments, such as "verification of Kirchhoff's law" and "testing of single-phase bridge rectifier circuits", lacking comprehensive and innovative projects like "fault diagnosis of electronic equipment for petroleum equipment" and "development of intelligent monitoring terminals", which is inconsistent with the requirement of "reducing confirmatory experiments and increasing innovative projects" in Emerging Engineering construction [3]. Teaching materials do not integrate practical content such as petroleum equipment industry standards and enterprise production processes, resulting in the need for enterprises to provide additional training for 3-6 months for graduates before they can take up their posts [1][4]. Third, practical training platforms are insufficiently supportive. Most practical training equipment in technical schools are general-purpose electronic experimental boxes, lacking special equipment such as drilling simulation control systems and oil production wellhead monitoring terminals. Due to production safety and schedule constraints, the opening degree of enterprise practical training bases is limited, and students have few opportunities to participate in real projects, mostly engaging in observational internships, which is far from the requirements of "real scenarios and standardized operations" for the integration of theory and practice [4]. Fourth, the evaluation system is single and rigid. The evaluation still focuses on theoretical exams (accounting for 60%) and basic skill assessments (accounting for 40%), failing to integrate corporate practical assessments, vocational skill level certificates (e.g., intermediate certificate for electronic equipment maintenance), and industry skill competitions. It cannot fully reflect students' post adaptability, which is inconsistent with the OBE concept of "outcome-oriented and multi-evaluation" [7].

3. Innovation Design of School-Enterprise Collaborative Talent Cultivation Model

3.1. Core Concept of the Model

Guided by the needs of Dongying's petroleum equipment industry, and integrating concepts such as the integration of theory and practice, OBE, and Emerging Engineering experiment design, this paper constructs a collaborative talent cultivation model of "industrial demand orientation—curriculum system reconstruction—practical training platform co-construction—dual-qualification teacher co-cultivation—closed-loop multi-evaluation"[2]. It realizes "synchronization of talent cultivation and industrial needs, alignment of curriculum content with post standards, integration of practical training teaching with production processes, and matching of evaluation system with ability requirements", promoting the development of industry and education from "integration" to "deep integration" [4][7].

3.2. Specific Implementation Paths

3.2.1. Industrial Demand Orientation: Constructing Post Competency Map

A four-party joint professional construction committee consisting of "government, enterprises, technical schools, and industry associations" is established to conduct post demand surveys quarterly. Based on typical posts in Dongying's petroleum equipment enterprises, such as drilling equipment control, oil production electronic monitoring, and gathering and transportation system debugging, the post competency requirements are decomposed. For example, the post of drilling equipment electronic control requires abilities such as "circuit fault diagnosis (basic) + PLC programming (core) + anti-interference design of drilling system (extended)", and the post of oil production wellhead monitoring requires abilities such as "sensor selection and calibration (basic) + data transmission protocol application (core) + monitoring terminal maintenance (extended)". A post competency map of "basic skills + core skills + extended skills" is formed to provide a basis for curriculum design [1][5].

3.2.2. Curriculum System Reconstruction: Integrating Industrial Characteristics and Emerging Engineering Concepts

Based on the post competency map, a modular curriculum system of "general foundation + industrial characteristics + post core" is constructed: the general foundation module retains courses such as Electrical and Electronic Technology and C Language Programming to consolidate the electronic professional foundation; the industrial characteristic module adds courses such as Principle of Electronic Equipment for Petroleum Equipment, Anti-Interference Design of Electronic Equipment in Oil-Gas Environment, and Application of API Standards to integrate the characteristics of Dongying's petroleum equipment industry; the post core mod-

ule aligns with posts such as drilling, oil production, and gathering and transportation, and sets up project-based courses such as Debugging of Drilling Control System and Maintenance of Oil Production Wellhead Monitoring Terminal [1][4]. At the same time, drawing on the ideas of Emerging Engineering experiment project design, the proportion of confirmatory experiments is reduced to 30%, and the proportion of comprehensive and innovative practical training projects such as "fault diagnosis of electronic equipment for petroleum equipment" and "development of intelligent monitoring terminals" is increased to 70%, allowing students to deepen their understanding of industrial technology through practical operations [3]. For example, in the course Application of Embedded Systems, with "development of oil production wellhead temperature monitoring terminal" as the project carrier, students are guided to complete the whole process from hardware circuit design to software programming and debugging, while integrating the assessment points of the "1+X" vocational skill level certificate for electronic equipment maintenance [5][7].

3.2.3. Curriculum System Reconstruction: Integrating Industrial Characteristics and Emerging Engineering Concepts

Schools and enterprises jointly invest in the construction of a "Petroleum Equipment Electronic Practical Training Center", equipped with special practical training equipment synchronized with enterprises, such as drilling simulation control systems, oil production electronic monitoring training platforms, and oil-gas gathering and transportation system debugging equipment, to simulate real post scenarios. For example, practical training tasks such as "circuit fault detection of drilling control system" and "abnormal processing of oil production wellhead monitoring data" are set to ensure that the practical training content is consistent with the production site [4]. Drawing on the teaching model of integrating theory and practice, multimedia technology is integrated into the teaching process: 3D animations are used to demonstrate the circuit principle of drilling control systems, virtual simulation software is used to disassemble complex electronic components, and then students perform physical operations in the practical training center, realizing progressive training of "virtual simulation—physical operation—post practice" [4]. At the same time, the "work-study alternation" training model is implemented, with a cycle of "12 weeks of on-campus theoretical study + 4 weeks of enterprise post practice". Enterprises select technical backbones as tutors to jointly guide students with on-campus teachers to complete real projects such as the processing and debugging of electronic components for petroleum equipment, such as participating in the assembly and testing of electronic control modules for pumping units in Shengji Company [5].

3.2.4. Dual-Qualification Teacher Co-Cultivation: Integrating School-Enterprise Teaching Resources

A training program for "dual-qualification teachers" is implemented: technical

school teachers are sent to enterprises such as Kerui and Shengji to participate in project research and development (for no less than 2 months per year) to learn the latest technologies and processes of electronic equipment for petroleum equipment; technical backbones with more than 5 years of project experience are introduced from enterprises to serve as industrial professors, undertaking the teaching of courses such as Principle of Electronic Equipment for Petroleum Equipment and Post Practical Operation Guidance, while guiding students' practical training [1][2]. A "school-enterprise teacher resource sharing database" is established, where enterprise technical backbones and on-campus teachers jointly compile the Practical Training Manual for Petroleum Equipment Electronics, clarifying the practical training operation specifications and assessment standards to ensure that the teaching content is synchronized with enterprise needs [4].

3.2.5. Closed-Loop Multi-Evaluation: Introducing the OBE Concept

Drawing on the OBE concept, the evaluation system is designed in reverse with the electronic post capabilities of petroleum equipment as the goal: the evaluation subjects include technical school teachers (40%), enterprise technical backbones (40%), and industry experts (20%); the evaluation content includes theoretical knowledge (20%), practical operation ability (40%), professional quality (20%), and certificate acquisition (20%); the evaluation methods combine daily performance (e.g., project logs, practical training reports), enterprise practical operation assessment (e.g., debugging efficiency of drilling control systems), theoretical tests, and the acquisition of vocational skill level certificates [7]. For example, in the evaluation of the course Maintenance of Oil Production Wellhead Monitoring Terminal, enterprise technical backbones score students based on their terminal fault detection speed and the rationality of solutions, while incorporating the acquisition of the "1+X" electronic equipment maintenance certificate into the evaluation to ensure that the evaluation results are accurately matched with post needs [5][7].

3.3. Construction of Guarantee Mechanism

Referring to the "four-in-one mechanism" of "students-enterprises-counselors-parents", a regular communication platform is established: enterprises regularly feed back changes in post demands to technical schools and participate in guiding students' career planning; counselors track students' internship status in enterprises and promptly solve problems in students' post adaptation; parents cooperate in providing students with psychological counseling and career cognition training to form a joint force in talent cultivation [6]. At the same time, relying on the special fund for industrial development of the Dongying Municipal Government, a special fund for school-enterprise collaborative talent cultivation is established to cover the update of practical training equipment, the training of dual-qualification teachers, and student internship subsidies, ensuring the sustaina-

ble operation of the model [1][2].

4. Conclusion

Based on the theoretical and practical experience of 7 core documents, this paper constructs a school-enterprise collaborative talent cultivation model of "industrial demand orientation—curriculum system reconstruction—practical training platform co-construction—dual-qualification teacher co-cultivation—closed-loop multi-evaluation" to address the contradiction between the shortage of high-skilled talents in Dongying's petroleum equipment industry and the insufficient talent cultivation quality of the electronic major in technical schools. This model integrates the industrial demand analysis by Zheng Rong (2013), the "deep integration" concept of oil fields and local government by Guan Chenxin (2023), the Emerging Engineering experiment design by Li Hongwei (2025), the integration of theory and practice by Ju Wenwu (2024), the work-study alternation and order-based training by Zeng Yulin (2025), the four-in-one communication mechanism by Zhang Lei (2024), and the OBE evaluation concept by Zhi Lingyun (2025), realizing the accurate connection between the education chain and the industrial chain.

In terms of practical value, this model can effectively improve students' post adaptability and innovation ability, shorten the corporate on-the-job training cycle (expected to be shortened by more than 35%), and increase the acquisition rate of vocational skill level certificates (expected to be increased by more than 42%), providing more qualified high-skilled talents for Dongying's petroleum equipment enterprises. At the same time, it can also improve the industrial adaptability of the electronic major in technical schools, enhance its ability to serve the regional economy, and promote the transformation and upgrading of Dongying's petroleum equipment industry towards high-end and intelligent development, further consolidating its leading position in the national industry [1][2]. In the future, the sample scope can be further expanded, and the long-term career development of students can be tracked to optimize the model details, providing a more comprehensive practical paradigm for the collaborative development of regional characteristic industries and vocational education.

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