

# Research on the Construction of the Professional Comprehensive Quality Training System for Excellent Field Engineers from the Perspective of New Quality Productive Forces

Yong Lv, Youpeng Huang, Ying Zhong

Beijing Institute of Economics and Management, Beijing 100102, China

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** Driven by new quality productive forces, the digital industry demands higher professional competencies from talent. Addressing the pain points in traditional industry-education integration talent cultivation models—such as fragmented school-enterprise collaboration and insufficient practical training—this study constructs a comprehensive training system for excellent field engineers, encompassing a “three-dimensional competency model, four-stage practical training system, and five-dimensional guarantee mechanism.” The system employs technologies such as blockchain-based credentialing and digital profiling to achieve precise process management. The research provides solutions for advancing the digital transformation of vocational education and supports the cultivation of high-quality engineering talent under the demands of new quality productive forces.

**Keywords:** New quality productive forces; Excellent field engineers; Comprehensive competencies; Practical training

**Online publication:** April 26, 2025

## 1. Literature review

New digital skill demands under new quality productive forces: Data has emerged as the most critical factor of production, leading to the proliferation of emerging positions and a mismatch between talent supply and industrial demand. Digital competency has become the core competitiveness of field engineers in the context of new quality productive forces. Engineers are required to possess digital-intelligent literacy, enabling the application of digital technologies in advanced manufacturing <sup>[1]</sup>. Under these forces, field engineers must develop a compound competency structure integrating data analysis, intelligent decision-making, smart equipment operation, and algorithmic optimization.

Multi-stakeholder collaboration for digital talent cultivation: Government guidance and policy support are essential for building integrated school-enterprise enrollment and training systems <sup>[2]</sup>. Jointly established field engineer colleges should adopt a “dual-subject” model to cultivate talents proficient in operation, process management, collaboration, and innovation. Scholars proposed a tripartite linkage mechanism (government guidance, industry coordination, school-enterprise collaboration) to foster industry-education communities for technology transfer. Effective collaboration requires a stable “policy-resource-benefit” triangle, with governments transitioning from regulators to facilitators via legislation,

funding, and evaluation reforms <sup>[3]</sup>.

School-enterprise collaborative resource development: Curriculum systems must prioritize emerging technologies and interdisciplinary integration, enhancing practical courses to align with industrial needs. Scholars advocated a multi-stakeholder education model involving governments, enterprises, schools, and public organizations <sup>[4]</sup>. Others designed a project-driven, industry-integrated practical curriculum, co-developing project repositories with enterprises to ensure dynamic alignment. They also emphasized workplace-oriented course design—“by, in, and for the workplace”—to strengthen vocational education’s industrial adaptability <sup>[5]</sup>.

Research gaps: Existing studies reveal critical limitations in cultivating excellent field engineers: (1) Practical deficiencies: Insufficient workplace-based learning, ambiguous theory-practice hour allocation, and weak integration between on-campus training and off-campus internships; (2) Collaboration barriers: Unclear rights, obligations, and responsibilities in school-enterprise partnerships, limited engagement from large enterprises, and inadequate project coverage; (3) Skill gaps: Lack of workplace-aligned training conditions to enhance digital literacy and innovation capabilities <sup>[6]</sup>.

Research innovation: To address these gaps, this study constructs a comprehensive framework comprising a “three-dimensional competency model, four-stage practical training system, and five-dimensional guarantee mechanism.” Key innovations include: (1) Dynamic post matrix design: Aligning talent development with industrial demand through competency mapping; (2) Dual-subject contractual management: Clarifying roles via legally binding school-enterprise agreements. This framework provides theoretical and practical guidance for transforming vocational education paradigms, ensuring precise alignment between talent cultivation and new quality productive forces <sup>[7]</sup>.

## 2. Three-dimensional competency model for excellent field engineers

### 2.1. Technological integration and innovation competency

This dimension focuses on interdisciplinary knowledge integration and technological iteration adaptability, supported by a modular curriculum system and a “dual-qualified” instructor team (academic and industry-experienced). Engineers are required to construct a “data-information-control” triadic knowledge framework, encompassing: Emerging technology mastery, including proficiency in AI, blockchain, big data, and IoT principles, with the ability to achieve real-time mapping between physical systems and virtual models via digital twin technology <sup>[8]</sup>.

Technology deconstruction and re-innovation: Capacity to innovatively refine complex processes using theoretical frameworks (e.g., TRIZ methodology). Dynamic knowledge renewal: Commitment to continuous learning, with annual completion of  $\geq 80$  training hours on emerging technologies to maintain technical acuity <sup>[9]</sup>.

### 2.2. Engineering practice and complex system decision-making competency

This dimension emphasizes technical implementation and resource coordination in real-world production scenarios, structured across three tiers: (1) Basic tier: Execute standardized operations with precision (e.g., operational compliance rate  $> 99\%$ ). (2) Advanced tier: Demonstrate multivariable collaborative optimization capabilities, balancing quality, cost, and efficiency through methodologies like PDCA cycles. (3) Elite tier: Master complex system decision-making using systemic models (e.g., system dynamics for technical roadmap planning). Cultivation pathways rely on a “cognitive-specialized-post rotation” three-phase practical system, leveraging enterprise projects (e.g., smart production line optimization) for competency enhancement <sup>[10]</sup>.

### 2.3. Professional ethics and sustainable development leadership

This dimension shapes engineers’ value rationality and technological ethics through three pillars: (1) Trinity of professional standards: Adherence to “safety-quality-environmental” protocols (e.g., ISO 45001 compliance). (2) Ethical decision-making: Balancing efficiency pursuits with humanistic considerations (e.g., retaining human oversight nodes in AI-driven

systems). (3) Sustainable innovation leadership: Championing green technologies (e.g., circular manufacturing achieving  $\geq 90\%$  material utilization). Training integrates specialized courses like “Technology Ethics Workshops” and “Carbon-Neutral Project Practicums,” fostering an integrated value system merging technical rationality, humanistic awareness, and ecological responsibility <sup>[11]</sup>.

### **3. Construction of a four-stage practical training system for excellent field engineers**

#### **3.1. Cognitive practice and professional enlightenment system**

The cognitive practice stage focuses on foundational engineering field awareness and professional literacy development. Through “front-factory-back-school” training bases co-built by schools and enterprises, production lines are integrated into educational environments. First-year students complete tasks such as occupational competency mapping and skill documentation, while safety regulation courses incorporating real enterprise cases strengthen responsibility awareness. A dynamic elimination mechanism screens trainees based on competency attainment rates (e.g.,  $\geq 85\%$  skill compliance), ensuring foundational competency benchmarks and preparing students for advanced practical training <sup>[12]</sup>.

#### **3.2. On-the-job training and tiered competency advancement**

Centered on project-based learning, this stage establishes a three-tier project system (single-course, cross-course cluster, and interdisciplinary comprehensive projects) within school-enterprise joint laboratories. A dual-mentor team—comprising enterprise engineers (guiding technical implementation) and academic instructors (providing methodological frameworks)—collaborates on real-world projects (e.g., smart production line optimization). Competency evaluation employs IoT devices (e.g., smart ID badges, AR glasses) to collect real-time operational data, constructing a 12-indicator “competency growth curve” model for personalized skill development <sup>[13]</sup>.

#### **3.3. Post-specific practice and technological innovation conversion**

Students engage in core enterprise roles (e.g., R&D centers) under dual-mentor guidance, completing technical improvement reports or patent applications, with enterprise expert evaluations constituting 50% of final assessments. A dual-certificate integration system embeds industry certifications (e.g., Siemens Mechatronic Certification) into curricula, accelerating technological achievement transformation rate (e.g., utility model patents) and shortening job adaptation cycles (by 42% in pilot cases) <sup>[14]</sup>.

#### **3.4. Closed-loop feedback and system optimization**

Blockchain technology authenticates practical achievements and generates student digital profiles. Schools and enterprises jointly monitor resource allocation and educational outcomes via an industry-education integration information platform, driving annual curriculum technology refresh rate  $> 15\%$ . Longitudinal tracking of graduate metrics—including three-year promotion rates (42% in pilot programs), employer satisfaction (92%), and salary benchmarks—validates system efficacy. This four-stage work-study alternation model, supported by institutionalized resource guarantees, resolves industry-education disconnects and provides a replicable paradigm for cultivating excellent field engineers under new quality productive forces <sup>[15]</sup>.

### **4. Five-dimensional guarantee mechanism for cultivating excellent field engineers**

Resource coordination and supply mechanism: Schools and enterprises dynamically match practical post resources based on production scale and technical complexity, establishing a “headquarters + satellite factories” distributed practical network. This ensures the number of practical training positions aligns with industrial demand, enabling students to access

multi-level technical scenarios (e.g., core R&D and peripheral production units).

**Dual-mentor instructional configuration:** Enterprise mentors lead practical training (monthly  $\geq 16$  instructional hours), focusing on technical implementation, while academic instructors deliver theoretical teaching. This technology-methodology synergy ensures students master both operational skills (e.g., CNC programming) and systemic thinking frameworks.

**Risk-sharing safeguard mechanism:** A dedicated risk fund covers accident insurance (e.g., workplace injury coverage) and equipment depreciation compensation (e.g., 30% cost-sharing for device maintenance). Joint risk warning and resolution protocols are established, with predefined escalation paths for emergencies (e.g., production line failures).

**Outcome sharing and distribution mechanism:** A tripartite “school-enterprise-student” intellectual property (IP) profit-sharing model clarifies rights to technological achievements (e.g., patent ownership ratios: 50% enterprise, 30% school, 20% student). This incentivizes innovation participation and accelerates technology commercialization (e.g., 35% increase in patent applications from pilot programs).

**Process quality monitoring mechanism:** Blockchain technology authenticates practical training data (e.g., equipment operation logs), while AI-driven analytics track competency growth curves in real time. This enables dynamic optimization of training plans (e.g., adjusting curriculum focus areas quarterly) based on performance metrics (e.g., skill mastery rates).

## Funding

- (1) 2023 Ministry of Education Humanities and Social Sciences Research Planning Fund Project “Research on the Cultivation Model of High-Quality Field Engineers from the Perspective of a Skill-Oriented Society” (23YJA880036)
- (2) Beijing Municipal Education Science “14th Five-Year Plan” 2021 Research Project Innovation and Practice of Talent Cultivation Models for Professional Cluster Apprenticeship System with Chinese Characteristics under the Integration of Industry and Education (CBAA21051)
- (3) Beijing Municipal Education Science “14th Five-Year Plan” 2024 General Project “Innovation and Practice in the Talent Training Model for Field Engineers in the Artificial Intelligence Era” (CDAB24288)
- (4) R&D Program of Beijing Municipal Education Commission (SM202114073001)
- (5) Digital Finance and Technology Innovation Team (22KJTD02)

## Disclosure statement

The authors declare no conflict of interest.

## References

- [1] Wang ZM, Guo GP, Xu L, 2024, The Internal Logic and Practical Approaches to Cultivating Field Engineers under the Impetus of New Quality Productive Forces. *Chinese Vocational and Technical Education*, (22): 52–63 + 78.
- [2] Xu L, Wang ZM, Meng XP, et al., 2025, Workplace Learning: A Study on the Cultivation Path of Field Engineers Adapting to the Demands of New Quality Productive Forces. *Chinese Vocational and Technical Education*, (4): 90–99 + 112.
- [3] Guo GP, He JS, Xu L, 2025, Research on Cultivating Vocational Education Field Engineers from the Perspective of New Quality Productive Forces. *Education and Vocation*, (1): 54–59.
- [4] Qiu LJ, Lai WJ, Lei QH, 2023, On the Fourfold Logic of Cultivating Field Engineers in Vocational Education. *Vocational and Technical Education*, 44(11): 43–48.
- [5] Cao LC, 2023, Research on the Value, Challenges, and Reform Strategies for High-Quality Cultivation of Field Engineers in Vocational Education. *Education and Vocation*, (3): 52–58.

- [6] Liu XZ, Xu B, Xu J, 2024, Building Industry-Education Integration Communities: Value Implications, Practical Dilemmas, and Promotion Strategies. *Education and Vocation*, (13): 23–30.
- [7] Liu YC, Lu BL, 2024, Cooperative Mechanisms and Optimization Pathways for Cultivating Field Engineers in Vocational Education from the “Joint Supply” Perspective. *Chinese Vocational and Technical Education*, (3): 28–35.
- [8] Liu SQ, Bian R, Zhu SQ, et al., 2025, Constructing a Practical Curriculum System for Outstanding Engineers Based on Industry-Education Integration and Project Leadership. *Laboratory Research and Exploration*, 44(3): 166–169 + 173.
- [9] Lou P, Liu GL, Weng ZK, 2024, Constructing Higher Vocational Professional Courses for Field Engineer Cultivation: Implications, Logic, and Strategies. *Vocational and Technical Education*, 45(32): 20–26.
- [10] Tian B, 2025, Exploration of Computer Talent Cultivation Mode in Higher Vocational Colleges Based on Industry-Education Integration. *Education Reform and Development*, 7(3): 21–26.
- [11] Kong T, Feng L, Guo Q, 2025, Innovative Research on Digital Talent Cultivation Mode of Higher Vocational Innovation and Entrepreneurship Education Promoted by Industry-Teaching Integration. *Applied Mathematics and Nonlinear Sciences*, 10(1).
- [12] Zhou Y, 2025, Research on Informationized Teaching Resources Integration of Talent Cultivation Mode in Higher Vocational Innovation and Entrepreneurship Education Promoted by Industry-Teaching Integration. *Applied Mathematics and Nonlinear Sciences*, 10(1).
- [13] Han B, Ma B, Li S, et al., 2024, Integration of Science and Education, Innovation and Education-reform and Practice of “ASK” Special Talent Training Model for Cyberspace Security Major. *Journal of Educational Research and Policies*, 6(12): 21–24.
- [14] Zhang H, 2024, The Training Mode of Innovative and Entrepreneurial Talents in Business Administration from the Perspective of Integration of Industry and Education. *Trends in Social Sciences and Humanities Research*, 2(11).
- [15] Liu Y, 2024, Research on the Talent Training Mode of Integration of Industry and Education in International Cruise Crew Management under the “1+X” Certificate System. *New Explorations in Education and Teaching*, 2(12).

**Publisher’s note**

*Whioce Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.*