

The Impact and Optimization Strategies of Industry-Education Integration on Talent Cultivation in Higher Vocational Colleges under New Quality Productive Forces

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Abstract: New quality productive forces have set forth new requirements for talent cultivation in higher vocational colleges, demanding graduates who possess professional skills, innovative thinking, and digital literacy in equal measure. Yet a structural mismatch persists between prevailing cultivation models and industrial needs, leaving industry-education integration wide in reach yet shallow in substance. This study constructs a “tripartite synergy – competency alignment – dynamic optimization” framework and examines the mechanisms through which industry-education integration shapes talent cultivation. Drawing on questionnaire surveys, in-depth interviews, and case studies of 175 enterprises, three representative higher vocational colleges, and multiple government agencies and industry associations, we find that: within tripartite synergy, enterprise participation remains largely transactional—mostly limited to accepting interns—while deeper engagement in curriculum development and technology co-construction remains scarce; in competency alignment, although enterprise demands are clearly articulated, institutional supply is misaligned, with digital and green competency development lagging behind; the dynamic optimization mechanism, though preliminarily established, responds too slowly to technological shifts, and traditional enterprises undergoing transformation participate at notably low levels. To address these challenges, we advance strategies along three lines: redefining the enterprise role, building agile institutional response capacities, and strengthening government policy incentives. These measures are intended to inform both the theory and practice of vocational education reform and

collaborative talent development.

Keywords: New Quality Productive Forces; Industry-Education Integration; Higher Vocational Colleges; Tripartite Synergy; Talent Cultivation; Optimization Strategies

1. Introduction

New quality productive forces, guided by scientific and technological innovation, anchored in digital integration, and oriented toward green and low-carbon development, deeply converge cutting-edge technologies — such as next-generation information technology, new energy, and advanced materials — with advanced manufacturing. This convergence has given rise to entirely new industrial ecosystems, including intelligent production, green manufacturing, and cross-sector integration, posing unprecedented demands on workforce quality structures and vocational competency systems. At this critical juncture of transformation, higher vocational colleges, as the primary arena for cultivating skilled technical talent, bear the responsibility of supplying well-matched graduates for the advancement of new quality productive forces, while industry-education integration stands as the core strategic pathway for resolving talent supply-demand mismatches and elevating cultivation quality.

Yet a pronounced structural mismatch persists between prevailing talent cultivation models in higher vocational colleges and the requirements of new quality productive forces: traditional teaching systems place excessive emphasis on theoretical knowledge transmission, with the incorporation of emerging technologies lagging significantly behind; curriculum update cycles are excessively long, failing to keep pace with rapid industrial technological iteration; and practical training remains largely confined to simulated settings, leaving students without

hands-on experience in real industrial projects. Meanwhile, industry-education integration practice also confronts tangible difficulties, including insufficient collaboration depth, poor information exchange, and a lack of cross-regional and cross-industry resource integration. In light of these challenges, this study constructs a “tripartite synergy – competency alignment – dynamic optimization” theoretical framework. Drawing on 175 enterprises and 3 higher vocational colleges as research subjects, and employing a combination of questionnaire surveys, case analysis, and in-depth interviews, it systematically examines the mechanisms through which industry-education integration shapes talent cultivation. Optimization strategies are proposed from the perspectives of enterprises, colleges, and government, offering reference for vocational education reform and collaborative talent development.

2. Literature Review

Research on industry-education integration and the collaborative development of vocational education has a long history. The theoretical underpinnings of linking vocational education with industry were first explored, outlining the basic architecture of school-enterprise cooperation and laying an important foundation for subsequent research [1]. The mechanisms for aligning curriculum reform with industrial demands have been examined in depth, proposing a work-process-based curriculum development approach that effectively shifted vocational education from a theory-biased orientation toward a practice-oriented one [2]. Internationally, the UK's “sandwich” curriculum model — in which alternating periods of work and study significantly enhance students' practical proficiency and overall professional competence — has been comprehensively analysed, establishing it as a classic global example of vocational education – industry integration [3].

Research on new quality productive forces has emerged as a hot frontier in recent years. The connotation of new quality productive forces has been systematically defined, with in-depth analysis of its technology-led, innovation-driven characteristics and the mechanisms through which it reshapes industries, thereby constructing a key industrial-economic

theoretical foundation for talent cultivation research in the education field [4]. From a macro perspective, the evolving patterns of workforce quality structures amid technology-innovation-driven industrial transformation have been examined, providing an international comparative lens for talent cultivation demand analysis [5].

In the deepening study of industry-education integration, the cross-boundary nature of vocational education has been further elaborated, advocating the dismantling of barriers between education and industry and the construction of an integrated collaborative talent cultivation system [6]. A collaborative development pathway linking industrial clusters with vocational education specialty clusters has been proposed [7]. Building on this, the vision of a regional industry-education integration ecosystem has been put forward, though how to ensure its dynamic adaptability amid rapid industrial change remains to be refined [8]. Australia's TAFE system has been found to achieve close education – industry synergy through deep industry-led curriculum development and comprehensive enterprise participation in teaching practice, yet adaptability challenges in localized transplantation still persist [9].

On faculty development, the pivotal role of dual-qualified teachers in elevating vocational education quality has been emphasized [10]. The enterprise-led talent cultivation mechanism and teacher selection and training system under Germany's “dual system” have been analysed in detail, offering important reference points for faculty development across countries [11]. Regarding emerging technology integration, the embedding pathways of artificial intelligence in vocational education curricula have been a focus, providing cutting-edge theoretical guidance for curriculum innovation driven by new quality productive forces [12]. The current status and challenges of digital technology application in vocational education teaching have been investigated through empirical research [13]. The transformation pathways of vocational education specialty settings and teaching methods under Industry 4.0 have been explored, emphasizing the cultivation of students' interdisciplinary competencies and innovative thinking [14]. The demand trends for green-skilled talent driven by the rise of green industries have been described [15]. The policy

evolution of government promotion of vocational education – industry cooperation has been comprehensively reviewed, providing international experience for optimizing policy design [16]. A practical teaching quality assessment system has been developed through empirical research, verifying its effectiveness in enhancing students' practical abilities [17]. The impact mechanisms of industry-education integration on vocational education quality assurance systems have been analysed, proposing a multi-stakeholder quality assessment framework [18].

In sum, existing research has made significant contributions to industry-education integration theory and practice from multiple dimensions, yet systematic and dynamic studies on talent cultivation in higher vocational colleges under the new quality productive forces paradigm still leave room for expansion. Building on these findings, this study constructs a “tripartite synergy – competency alignment – dynamic optimization” framework to systematically explore the mechanisms through which industry-education integration shapes talent cultivation in higher vocational colleges and to propose optimization strategies accordingly.

3. Theoretical Framework

Anchored in the defining traits of new quality productive forces, where technological innovation serves as the driving engine, digital integration occupies the core position, and green low-carbon development sets the directional orientation, this study identifies persistent structural contradictions in current industry-education integration practice. These contradictions include inadequate depth of collaboration and a clear mismatch between talent competencies and what industries actually demand. To address them, a systematic theoretical framework titled “Tripartite Synergy – Competency Alignment – Dynamic Optimization” has been constructed, offering both logical guidance and practical pathways for talent cultivation in higher vocational colleges. The framework draws on Foster's school-enterprise cooperation theory and innovation ecosystem theory reviewed in the literature, while weaving in the fresh competency expectations that new quality productive forces impose. The result is a progressive logical chain that moves from stakeholder synergy, through

competency shaping, to mechanism optimization. Within the Tripartite Synergy dimension, the framework foregrounds deep interaction among government, enterprises, and higher vocational colleges, all grounded in mutual interest coupling. The goal is to break past the bottleneck of what has largely remained shallow-level participation in school-enterprise cooperation. Acting as the institutional supplier, the government must cultivate a new quality industry-education integration ecosystem by means of policy guidance and strategic resource allocation. One concrete step would be to design combined policies for private enterprises, which make up a large share of the sample, blending technology equity participation with tax incentives. Spending by enterprises on building shared technology platforms could be counted toward the enhanced tax deduction for research and development expenses. The government would also work with industry associations to draft a competency standard for new quality productive forces talent, specifying tiered certification systems for digital skills (such as industrial internet operation) and green skills (such as carbon footprint accounting), thereby providing rigid benchmarks for school-enterprise cooperation. Enterprises, in turn, need to shift from being traditional internship providers to technology communities, embedding their intelligent production scenarios and green technology resources deeply into the entire talent cultivation process. For example, they could integrate operation cases of artificial intelligence quality inspection systems into curriculum design, open new energy battery recycling production lines during practical training, and balance short-term costs with long-term talent reserve needs through a revenue-sharing mechanism tied to project outcomes. Higher vocational colleges, as the core carriers of talent cultivation, need to establish an agile response mechanism linking industry demand to specialty adjustment and curriculum update, build interdisciplinary specialty clusters combining digitalization with greening around the new quality productive forces industrial chain, and implement a dual-qualified faculty development program requiring professional teachers to participate regularly in enterprise technology research and development projects, ensuring that teaching content iterates in sync with industrial frontiers.

The Competency Alignment component focuses

on the compound competency requirements that new quality productive forces impose on talent, achieving dynamic balance between talent supply and industrial demand through curriculum system restructuring and teaching model innovation. Addressing the widely reported insufficiency of students' digital competencies, the framework proposes a three-dimensional competency module. At the digital skills level, courses such as Digital Twin Technology Application and Industrial Internet Platform Operation and Maintenance would be developed, with project-based teaching using real enterprise production data. At the green skills level, modules including Low-Carbon Production Process Design and New Energy System Integration would be added, with practical training reinforced through real-world tasks such as photovoltaic module recycling and carbon reduction scheme design. At the innovation competency level, a Micro-Innovation Workshop system would be introduced, requiring students to complete one enterprise technology improvement proposal per semester, directly responding to the innovation-driven core demand of new quality productive forces. In terms of teaching models, a dynamic update mechanism would be adopted to tackle the conceptual disconnection that enterprises frequently report. Interdisciplinary teaching teams would guide compound projects so that

students build cross-domain problem-solving abilities.

The Dynamic Optimization mechanism takes shape against the backdrop of rapid technological iteration and frequent demand shifts characteristic of new quality productive forces. It establishes a closed-loop feedback system that runs from technology monitoring, through competency assessment, to strategy adjustment. The government would spearhead the creation of a New Quality Technology Dynamic Database alongside enterprises and industry associations. This database would be updated quarterly with frontier technologies and job demand changes, automatically pushing skill alerts to colleges. Colleges, in turn, would generate a three-dimensional digital profile for each student, covering digital competency, green skills, and innovation potential, drawing on training platform data and enterprise internship evaluations to pinpoint weaknesses with precision. When alerts and profile results arrive, a micro-course development rapid response would be activated, practical projects would be adjusted on a regular basis, and the Tripartite Synergy policies and competency modules would be refined in light of annual enterprise satisfaction surveys. This ensures that talent cultivation stays continuously aligned with the evolving demands of new quality productive forces.

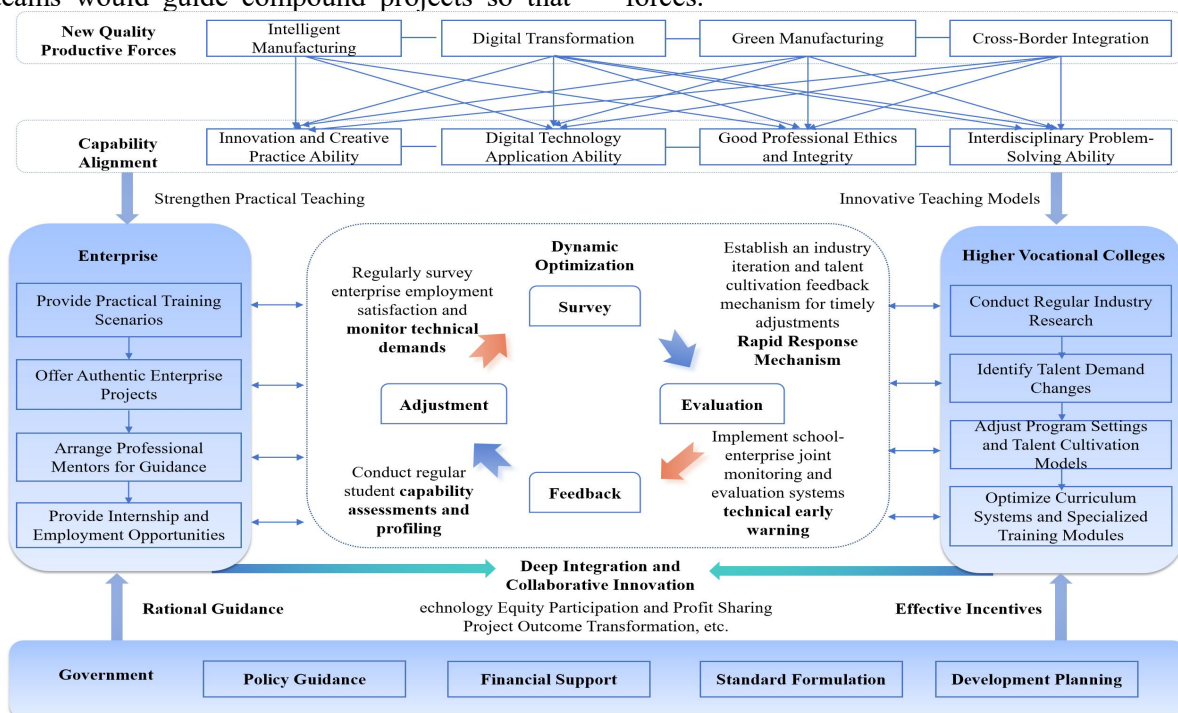


Figure 1. Theoretical Framework of “Tripartite Synergy–Competency Alignment–Dynamic Optimization”

By consolidating the cooperation foundation through Tripartite Synergy, shaping core competencies through Competency Alignment, and safeguarding long-term development through Dynamic Optimization, the three components advance in a progressive, mutually supportive fashion. Together they form the theoretical core and practical pathway of industry-education integration talent cultivation under new quality productive forces, as illustrated in Figure 1.

4. Research Design and Methodology

4.1 Research Subjects

This study takes the core participating entities in industry-education integration talent cultivation in the context of new quality productive forces as its subjects, encompassing enterprises, higher vocational colleges, government departments, and industry associations, thereby forming a

multi-dimensional analytical framework.

Enterprises. A core sample of 175 enterprises that maintain stable cooperative relationships with higher vocational colleges was selected. The sample selection accounts for both the industrial characteristics of new quality productive forces development and the practical contexts of industry-education integration, covering enterprises of diverse ownership types, scales, and technological profiles. This composition comprehensively reflects the differentiated demands and behavioral characteristics of enterprise participation in industry-education integration under new quality productive forces, providing an empirical foundation for analyzing the role positioning of enterprises within “tripartite synergy” and the talent demand orientation of “competency alignment.” The detailed sample structure is presented in Table 1.

Table 1. Sample Structure of 175 Enterprises

Dimension	Category	Count/Percentage	Core Characteristics and Research Value
Ownership Type	Private/Individual Enterprises	131 (74.86%)	Operationally flexible, with urgent demand for low-cost talent reserves under new quality productive forces; the primary participants in industry-education integration
	State-Owned Enterprises	15 (8.57%)	Resource-rich, emphasizing standardization in talent cultivation; reflect policy-oriented cooperation models
	Sino-Foreign Joint Ventures/Wholly Foreign-Owned Enterprises	10 (5.71%)	Bring international advanced technology and management concepts; reflect internationalization demands in talent cultivation
	Other Types	19 (10.86%)	Including mixed-ownership enterprises; provide diverse cases for industry-education integration
Enterprise Scale	Small (fewer than 100 employees)	76 (43.43%)	Focus on specific technology domains, emphasize practical skill development; align with foundational skill requirements in “competency alignment”
	Medium (100–1,000 employees)	70 (40.00%)	In growth stage, prioritize innovative thinking and teamwork capabilities; correspond to compound talent demands under new quality productive forces
	Large (more than 1,000 employees)	29 (16.57%)	Lead industrial upgrading, emphasize high-end technology R&D and comprehensive management talent; validate the depth of “tripartite synergy” cooperation
Enterprise Accreditation Type	Innovative/Specialized & New SMEs	73 (41.71%)	Strong demand for technological iteration, actively participate in curriculum co-construction and practical training; key feedback providers for the “dynamic optimization” mechanism
	Provincial/National “Little Giant” Enterprises	16 (9.14%)	Industry-leading, emphasize core technology talent cultivation; reflect talent demands in key areas of new quality productive forces
	National Manufacturing “Single Champion” Enterprises	7 (4.00%)	Focus on technological breakthroughs in niche segments; provide cutting-edge practical training scenarios; support digital and green skill development in “competency alignment”
	Other Types	79 (45.14%)	Including traditional enterprises undergoing transformation; enable comparative analysis of industry-education integration differences across industrial backgrounds

Higher Vocational Colleges. Three representative colleges with exemplary industry-education integration practices (e.g., Guangdong Mechanical & Electrical Polytechnic) were

selected. Their common characteristics align closely with the research needs: first, their specialty offerings are closely tied to the new quality productive forces industrial chain,

offering emerging programs such as intelligent manufacturing, new energy technology, and digital economy, while traditional programs have undergone digital transformation — this supports research on the curriculum system dimension of “competency alignment”; second, they possess a foundation of “dual-qualified” faculty (with over 70% dual-qualified teachers), and enterprise part-time instructors participate in core course instruction, enabling analysis of the faculty synergy mechanism within “tripartite synergy”; third, they have already implemented cooperation models such as modern apprenticeships and order-class programs, providing the teaching adjustment cases and data required for “dynamic optimization.”

Government Departments and Industry Associations. Government departments include local education authorities and industrial park management committees. Industry associations cover 12 organizations, including the Guangdong Logistics Industry Association. The analysis focuses on the impact of policy supply and industry standard formulation on industry-education integration.

4.2 Research Methods

A mixed-methods design that blends quantitative and qualitative approaches underpins this study. Questionnaire surveys, case analysis, in-depth interviews, and literature review are drawn upon to examine the “Tripartite Synergy – Competency Alignment – Dynamic Optimization” theoretical framework from multiple angles.

Questionnaire Survey. Questionnaires were sent to 175 enterprises, with items spanning cooperation formats, the degree to which elements of new quality productive forces have been integrated, and evaluations of talent competencies. All 175 responses proved valid, yielding an effective response rate of 100%. Descriptive statistics and differential analysis were performed with SPSS version 26.0, revealing structural contradictions within industry-education integration. For instance, only 50.29% of enterprises had participated in curriculum development, while cooperation preferences varied significantly across enterprises of different sizes.

Case Analysis. Two representative cases were selected for in-depth examination. The first involves a new energy enterprise and a higher

vocational college that jointly established a training center centered on photovoltaic and energy storage technologies, where digital twin technology was embedded into the instructional process. The second concerns a smart manufacturing enterprise that took part in formulating the Industrial Internet Skills Standard, thereby creating a closed loop connecting curriculum, certification, and employment. On-site visits, analysis of cooperation agreement texts, and in-depth interviews with school-enterprise stakeholders (3 enterprise executives and 5 college faculty members) were conducted to distill the practical experience underlying the “Tripartite Synergy” mechanism.

Interviews. Stakeholders representing government, enterprise, and college were interviewed. The sample comprised 20 enterprise technical managers, 15 higher vocational college program directors, and 5 government policy makers. Topics explored included motivations for cooperation, barriers to competency alignment, and policy needs. Coding analysis was employed to capture qualitative evidence of stakeholder interaction.

Literature Review. A systematic review of the literature was undertaken, covering industry-education integration theories (including Foster's school-enterprise cooperation theory), policy documents on new quality productive forces (such as the Opinions on Deepening the Reform of the Modern Vocational Education System), and relevant industry reports. These sources furnished both theoretical grounding and policy context for the present study.

Data Processing. Questionnaire reliability was confirmed by means of Cronbach's alpha coefficient and exploratory factor analysis. To safeguard the credibility of qualitative findings, triangulation and member checking were adopted.

5. Major Findings

5.1 Tripartite Synergy: Foundational Interaction but Insufficient Depth, Featuring Stratification and Barriers

Drawing on the “Tripartite Synergy – Competency Alignment – Dynamic Optimization” theoretical framework, and integrating quantitative survey data from 175 enterprises, interview materials from the three

representative higher vocational colleges, along with practical cases, the analysis reveals that tripartite synergy is characterized by broad coverage yet shallow substance.

At the enterprise level, 83.43% of the 175 sample enterprises regard hosting student internships or facilitating employment as their foundational form of cooperation, of which private and individual enterprises make up 74.86%. Driven by short-term cost concerns, merely 50.29% engage in curriculum development and only 7.43% jointly build common technology service platforms, with the core of cooperation centered on low-cost talent acquisition. By contrast, provincial or national “Little Giant” enterprises, which represent 9.14% of the sample, and national manufacturing “Single Champion” enterprises, standing at 4%, reveal deep synergy potential: 62.5% of “Little Giant” enterprises co-establish training centers with colleges, while 42.86% of “Single Champion” enterprises jointly pursue technology research, giving rise to a model that joint technology research with talent co-cultivation.

At the policy level, 68.57% of enterprises acknowledge the guiding function of financial and fiscal policies, and 29.71% of provincial-level industry-education integration enterprises have expanded their cooperation scale on the basis of these policies. The three representative colleges have restructured their specialty offerings around the new quality productive forces industrial chain, with dual-qualified teachers comprising 72% of the faculty. Nevertheless, rigid administrative procedures lead to an average curriculum adjustment cycle of six months, which falls behind the speed at which enterprise technology evolves. Meanwhile, 90.86% of enterprises display conceptual deviations regarding specialty operation, and 72.57% suffer from demand transmission misalignment stemming from differences in school-enterprise discourse systems. Imbalanced interests collectively serve as structural barriers to tripartite synergy.

5.2 Competency Alignment: Clear Enterprise Demands but Misaligned Institutional Supply, with Precision to Be Improved

Competency alignment centers on the compound requirements of digital, green, and innovation capabilities that new quality productive forces impose on talent. Enterprise demands follow a

dual-layer structure: foundational competencies form the base, while emerging competencies sit at the core. Quantitative data reveal that 72.57% of enterprises rank problem-solving ability as their top priority, 70.29% place high value on self-directed learning, and 72.57% stress teamwork. At the same time, 41.14% of enterprises explicitly call for digital competencies and 42.86% demand innovation capability. Among innovative, specialized, and newly established enterprises, the share of those requiring both types surpasses 60%. As for specifics, 32.57% of enterprises hold that digital competencies should center on tool operation, whereas 29.71% define innovation capability as the continuous refinement of technology improvement proposals rather than one-off outputs.

Institutional cultivation, however, falls significantly short of these demands. Traditional theoretical courses still make up more than half of the curriculum, and the average curriculum update cycle stretches to 1.5 years. Among school-enterprise co-built training bases, only 40% are able to offer training grounded in real production scenarios. This gap means that students typically need twice as long as enterprises expect to adapt after entering the workplace. Although enterprises attach the greatest weight to student on-the-job performance (importance score of 4.9) and the practicality of graduation projects (importance score of 5.0), merely 33.33% of colleges integrate enterprise evaluation into core assessment. The rest continue to rely mainly on theoretical exam scores.

The supply-demand mismatch runs even deeper when broken down by enterprise type. Small enterprises, which represent 43.43% of the sample, need basic operational skills that do not align with the comprehensive project training colleges offer. Large enterprises, making up 16.57% of the sample, demand high-end technology research and development capabilities that colleges struggle to support given the limited qualifications of dual-qualified teachers. Sino-foreign joint ventures and wholly foreign-owned enterprises, constituting 5.71% of the sample, value international collaboration competencies, yet course coverage for these skills remains below 15%. These gaps collectively widen the divide between what enterprises need and what institutions deliver.

5.3 Dynamic Optimization: Mechanism Preliminarily Established but Insufficient Efficacy, with Traditional Enterprise Participation as a Weak Link

The dynamic optimization dimension centers on a closed-loop feedback system that links technology monitoring, competency assessment, and strategy adjustment. Industry standards and technology monitoring have laid a foundational groundwork. Relevant group standards set out tiered certification systems for digital and green skills. The New Quality Technology Dynamic Database, built by the industry-education integration community, updates frontier technologies such as artificial intelligence quality inspection systems and low-carbon production processes on a quarterly basis. In 2024, it pushed 12 skill alerts to partner colleges, including one flagging a 30% surge in demand for a specific technology operation and maintenance skill. These outputs provide a data foundation for dynamic adjustment.

Nevertheless, the operational efficacy of the mechanism is held back by two shortcomings. The first concerns colleges' rapid response capacity, which remains inadequate. Merely 25% of colleges are able to supplement teaching content through micro-course development within one month of a technological update. The rest need three to six months. A concrete illustration: after a smart manufacturing enterprise introduced a new inspection technology, the college in question did not roll out the relevant training module until six months later, falling well behind the pace of industrial technological iteration. As many as 73.33% of colleges depend on annual enterprise satisfaction surveys to adjust cultivation strategies, which means they cannot capture short-term shifts in enterprise demand in a timely fashion. The three-dimensional digital profile of students, covering digital competency, green skills, and innovation potential, has been constructed by some colleges using training platform data and enterprise internship evaluations. Yet this profile serves only for individual ability assessment and is not connected to enterprise demands to produce targeted optimization solutions.

The second shortcoming lies in the notably low participation of traditional industry transformation enterprises. Among these enterprises, such as traditional manufacturers that have introduced smart production lines, 45.14% fail to contribute information feedback

to the New Quality Technology Dynamic Database due to insufficient technology awareness. Only 18.99% submit curriculum adjustment suggestions to colleges. As a result, their distinctive demands, such as skills for digital transformation of traditional production lines, are left out of the optimization scope. Student adaptation rates for these enterprises are 32% lower than those for innovative enterprises, marking them as the weak link in the dynamic optimization system.

6. Conclusion and Optimization Strategies

This study draws on data from 175 enterprises, three representative higher vocational colleges, government departments, and industry associations. Grounded in the "Tripartite Synergy - Competency Alignment - Dynamic Optimization" framework, the analysis reveals that while integration between industry and education has yielded positive results in strengthening practical operational skills, digital competencies, and professional qualities, three core contradictions persist.

The first lies in tripartite synergy, which is marked by broad participation yet uneven depth. Private and individual enterprises tend to engage at a superficial level, driven by short-term cost pressures, and only a fraction make substantive contributions to curriculum development. Meanwhile, rigid administrative procedures and gaps in discourse systems between stakeholders create structural barriers to deeper cooperation.

The second concerns competency alignment, where enterprise demands are clear but institutional supply falls short. Traditional theoretical courses still dominate the curriculum, training scenarios remain disconnected from real production environments, and the assessment system largely overlooks enterprise evaluation.

The third appears in dynamic optimization, where the mechanism is in place but operates with limited effectiveness. Colleges respond slowly to changes, and traditional enterprises show low willingness to participate. As a result, the pace of talent cultivation lags behind the speed of technological renewal.

To resolve these contradictions, coordinated efforts from enterprises, higher vocational colleges, and government and industry associations are needed to push the transformation of industry and education integration from superficial cooperation toward deep synergy.

(1) Enterprises: Shifting from “Talent Acquirers” to “Co Cultivation Communities”

Given that private and individual enterprises — which make up 74.86% of the sample — tend to engage at a superficial level driven by short-term cost pressures, and only a fraction make substantive contributions to curriculum development, a mechanism that aligns short-term inputs with long-term returns is essential.

One practical route involves integrating students directly into enterprise technical improvement workflows. Take smart manufacturing: students can operate AI quality inspection systems, participate in parameter debugging and fault diagnosis, and enterprises share a share of the resulting efficiency gains — lowering training costs while building a pipeline of job-ready graduates.

Meanwhile, leading enterprises — particularly “Little Giant” and “Single Champion” firms — should take the initiative in building joint technology research platforms with traditional firms undergoing transformation. These platforms would pool resources such as digital twins and carbon footprint accounting, help traditional firms identify their skill gaps, and push them to feed data into the New Quality Technology Dynamic Database, where their participation currently lags.

Beyond technical collaboration, industry-education integration should also be folded into corporate social responsibility assessments, so that investments in curriculum co-construction and training center development earn social credit bonus points — thereby reinforcing the incentive for sustained engagement.

(2) Higher Vocational Colleges: Building an “Agile Response, Precision Cultivation” System

The mismatch between outdated curricula and real workplace conditions calls for a fast-track channel that links industry demand directly to curriculum adjustment. Around the new quality productive forces industrial chain, interdisciplinary specialty clusters merging digitalization with greening need to be established — for instance, pairing new energy technology with digital twin, or smart manufacturing with carbon management. A micro-course development mechanism should also be put in place so that module supplementation can be completed within one month of a technology alert, such as when demand for certain operation and maintenance

skills rises sharply. At present, only a small number of colleges can meet this target.

Training bases, for their part, must be anchored in actual production scenarios. Colleges and enterprises should co-build facilities like new energy battery recycling lines and industrial internet operation and maintenance workshops, ensuring genuine operational conditions and shortening the post-hire adaptation period — which at present runs twice as long as enterprises expect.

Regarding faculty, the dual qualified teacher team should be expanded. Professional teachers need to spend a set number of days each year doing enterprise practice and joining new quality technology research and development projects, such as upgrades to artificial intelligence quality inspection systems. Enterprise technical managers should be recruited to teach core courses, reaching a required minimum threshold. The assessment system requires restructuring. Enterprise evaluation, covering internship performance and the quality of technical proposals, should be incorporated into core indicators with a weight no lower than a set proportion. Differentiated training modules should be offered to serve enterprises of varying sizes, moving away from a uniform approach to cultivation.

(3) Government and Industry Associations: Strengthening “Policy Incentives, Standard Guarantees”

To tackle problems such as weak policy incentives and gaps in discourse systems between schools and enterprises, both policy tools and standard systems need to be refined. The government could roll out a technology equity participation tax deduction policy, under which enterprise investments in curriculum co construction and training center development count toward research and development expense super deduction at a relatively high rate. The approval process for industry-education integration projects should be simplified, cutting the administrative cycle for college specialty adjustments and curriculum updates to under three months, compared to the current average which is considerably longer. This would prevent institutions from falling behind technological changes.

Industry associations should spearhead the development of a Detailed Competency Standard for New Quality Productive Forces Talent. This standard would refine certification procedures

for digital skills, such as graded industrial internet operation, and green skills, such as carbon footprint accounting qualifications. It would also help unify the cognitive frameworks of schools and enterprises, since the majority of enterprises currently hold biased views on vocational program concepts.

An information matching platform linking government, enterprise, and college should be set up. It would promote the alignment of students' three dimensional digital profiles, covering digitalization, greening, and innovation potential, with enterprise job requirements. At the same time, an international industry-education integration information platform should be created to introduce global talent cultivation standards. This would address the gap in international collaboration competency development among Sino foreign joint ventures and wholly foreign owned enterprises.

A special subsidy for traditional enterprise industry-education integration should also be established. It would provide a set amount of financial support to traditional enterprises that take part in new quality technology training and submit curriculum adjustment suggestions, thereby boosting their involvement in dynamic optimization.

Compared with existing studies, this research moves beyond the previous limitation of focusing on a single stakeholder. It systematically analyzes the issue from three dimensions: the synergy mechanism among enterprises, colleges, and government; the alignment between competency supply and demand; and the dynamic response to technological change. A mixed quantitative and qualitative methodology is adopted, making the findings more systematic and practically oriented. The practical implications are as follows. Colleges need to dynamically adjust their specialty structures and curriculum systems while increasing investment in dual-qualified faculty. Enterprises should engage deeply in curriculum co construction and technology joint research. The government needs to streamline administrative procedures, unify standards, and build information platforms.

The limitations of this study are as follows. The sample is predominantly concentrated in industrially active eastern regions, with a relatively low share from central and western regions. Industrial coverage focuses mainly on smart manufacturing and new energy, with

limited representation of fields such as the digital economy and biomedicine. The study also does not track students' long term career development after employment, which calls for follow up research to complete the transmission chain from individual cultivation to career development.

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