

Research on the Mechanism and Path for Realizing the Practical-Education Function of Municipal Industry-Education Consortiums

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Abstract: The municipal industry-education consortium serves as a strategic institutional carrier for the reform of China's modern vocational education system. Its core value lies in promoting the transformation of vocational-education practical education from shallow and loose university-enterprise collaboration to a paradigm of multi-agent substantive symbiosis through organizational-system innovation. Integrating the organizational boundary theory and symbiosis theory, this paper constructs an integrated analytical framework of "organizational form-operational contradictions-resolution paths", and systematically analyzes the internal realization mechanism of the practical-education function of municipal industry-education consortiums. The study shows that mature municipal industry-education consortiums have generally established a three-level governance structure of "council-specialized committee-operation and management center", and carry out collaborative education relying on platform-based organizational carriers and project-oriented operation modes. In the operation of consortiums, there persist three structural tensions of organizational boundaries: the solidified physical boundaries hinder the overall planning and integration of cross-domain resources; blurred social boundaries weaken the resultant force of multi-agent collaborative education; conflicts in psychological boundaries erode the foundational value consensus among participants. The endogenous root of the above-mentioned contradictions lies in the heterogeneous-logic game among government, industrial parks, industry associations, enterprises and vocational colleges. To resolve the dilemma of "formal integration without substantive convergence" in industry-education integration, it is necessary to build a symbiotic collaborative governance system, break physical barriers through substantive operation, straighten out agent relations via benefit coupling, bridge cognitive gaps with digital technologies, and accomplish the governance transition of consortiums from external administrative-driven forces to endogenous empowerment of the industry-education ecosystem. This research enriches the theoretical interpretation system for industry-education integrated collaborative governance, and provides practical policy references for the high-quality implementation of municipal industry-education consortiums and full release of practical-education effectiveness.

Keywords: Municipal Industry-education Consortium; Practical Education; Symbiotic Governance; Industry-education Integration.

1. Introduction

Deepening industry-education integration constitutes a core starting point for vocational education in the new era to improve quality and adapt to regional industrial transformation and upgrading. In December 2022, the General Office of the CPC Central Committee and the General Office of the State Council issued Opinions on Deepening the Reform of the Modern Vocational Education System, explicitly proposing to foster municipal industry-education consortiums with comprehensive functions of talent cultivation, innovation and entrepreneurship, and industrial empowerment, taking industrial parks as spatial supports. Subsequently, the Ministry of Education selected and announced 34 national-level pilot construction projects of municipal industry-education consortiums in two batches, marking that this institutional innovation has fully shifted from top-level policy design to implementation on the ground.

The institutional design of municipal industry-education consortiums addresses the enduring, chronic problem of the "disconnection between industry and education" that has long constrained vocational-education development. Traditional university-enterprise cooperation has largely remained at a superficial level—limited to signing framework agreements, erecting training-base plaques, and organizing short-term

on-the-job internships. It has been persistently plagued by issues such as "active colleges yet passive enterprises," fragmented cooperative relations, and poor circulation of high-quality resources. In contrast to the conventional point-to-point university-enterprise model, the municipal industry-education consortium takes industrial parks as spatial hubs, constructing a multi-agent collaborative network that encompasses governments, industrial parks, industry associations, enterprises, vocational colleges, and research institutions. Supported by substantive operational mechanisms as institutional guarantees, it aims to build a deeply integrated, long-term, and stable industry-education symbiotic ecosystem. Nevertheless, observations of regional pilot practices reveal that most consortiums remain trapped in the dilemma of "nominal union with substantive separation," where operational depth stays superficial and the core practical-education function fails to be fully realized. Hence, the core research questions emerge: What is the internal realization logic of the practical-education function within municipal industry-education consortiums? What organizational structure can sustain the long-term delivery of educational effectiveness? And how can we interpret the deep-seated structural incentives behind the various operational obstacles?

Existing academic research has accumulated multi-dimensional theoretical insights into municipal

industry-education consortiums. First, from an organizational-boundary perspective, studies have systematically identified three types of boundaries in consortium operation and demonstrated how physical, social, and psychological boundaries respectively inhibit deep inter-agent cooperation in terms of resource circulation, collaborative mechanisms, and value identity[1]. Second, within the framework of symbiosis theory, researchers have delineated bottlenecks restricting consortium development across the three dimensions of symbiosis unit, symbiosis relationship, and symbiosis environment, proposing progressive optimization pathways for evolving from shallow to deep symbiosis[2]. Additional contributions include analyzing the evolution logic of industry-education integrated training bases from an organizational ecology standpoint[3]; interpreting the organizational construction of regional industry-education integration with a focus on open regional practical centers; parsing multi-agent behavioral choices in the industry-education field using institutional logic theory[4]; and elucidating the conditions for cross-organizational collaboration through innovation-ecosystem theory. These scholarly achievements collectively lay a solid theoretical foundation for the present study[5].

Most existing studies focus on macro-interpretation of policy connotation, value orientation and construction modes of municipal industry-education consortiums and produce many enlightening outcomes, yet three limitations remain. First, systematic analysis centering on practical education, the core function of municipal industry-education consortiums, is absent. Most researches emphasize industrial empowerment and organizational innovation rather than specialized discussion on the realization mechanism of practical-education functions. Second, structural analysis of operational contradictions is insufficient. Existing studies mostly describe the phenomenon of “formal integration without substantive convergence” instead of exploring deep-rooted obstacles for multi-agent collaborative education from the perspective of organizational interaction. Third, prevailing optimization paths tend to be macro-policy advocacy, while constructing operable mechanisms for the implementation of practical-education functions is inadequate, which can hardly respond to practical demands of pilot reforms across regions. Against such research background, this paper takes the realization logic of practical-education functions of municipal industry-education consortiums as its core theme. It integrates organizational boundary theory and symbiosis theory to build an analytical framework. On the basis of sorting out the organizational-form characteristics and educational-support logic of consortiums, it deeply analyzes structural tensions and underlying incentives in their operation, and finally proposes targeted resolution paths. It is expected to enrich theoretical researches on industry-education integrated collaborative education and provide practical guidance for high-quality construction of municipal industry-education consortiums in China.

2. Theoretical Basis and Construction of the Analytical Framework

2.1. Organizational Boundary Theory: An Analytical Tool for Multi-agent Collaborative Interaction

Organizational boundary theory offers a foundational

analytical framework for interpreting cross-domain, multi-organizational collaborative behaviors. Within organizational sociology, scholars have observed that organizations establish differentiated boundaries through their interactions with external environments[6]. These boundaries function not merely as the basis for delineating power-responsibility scopes and professional divisions among agents, but also as inherent constraints on cross-organizational resource exchange and collaborative cooperation. Integrating insights from local industry-education integration practices, domestic scholars further delineate organizational boundaries into a three-dimensional system encompassing physical space, social roles, and psychological identity. Moreover, organizational boundaries exhibit dynamic evolution, continuously reconstructed in response to organizational strategic adjustments, shifts in external policy, and ongoing institutional iterations.

As cross-border cooperative organizations spanning the realms of education and industry, municipal industry-education consortiums hinge critically upon the precise identification, adept governance, and seamless integration of three fundamental boundaries for their overall operational effectiveness. Physical boundaries denote tangible segmentation barriers, such as disparate geographical locations, incompatible hardware facilities, and divergent technical standards; their ossification directly impedes the fluid sharing of resources across agents. Social boundaries are constructed by the distribution of agent power-responsibility, the frameworks of rules and regulations, and the mechanisms of benefit distribution. Blurred or misaligned social boundaries can trigger mismatched power-responsibility dynamics and fracture the very chains of collaboration. Psychological boundaries are rooted in deeper strata of organizational culture, divergent value concepts, and varied identity recognition; conflicts at this level will steadily erode the essential consensus required for sustained multi-party cooperation. Cultural surveys on university-enterprise cooperation conducted by Zhang Hua reveal that whether the practical-education effectiveness of municipal industry-education consortiums can be fully unleashed depends, in essence, on the effective penetration, integration, and ultimate elimination of these three organizational boundaries[7].

2.2. Symbiosis Theory: Logical Interpretation Framework for Industry-Education Ecosystems

Originating from research on species interdependence in biology, symbiosis theory has been widely applied to diverse fields, including cross-organizational cooperation and industrial-ecosystem governance. It was first introduced into Chinese social-science research, where the classic analytical paradigm of symbiosis unit, symbiosis mode, and symbiosis environment was proposed. Subsequently, domestic scholars imported symbiosis theory into vocational-education research[8]. This work refined the three-dimensional analytical paradigm of “symbiosis unit–symbiosis relationship–symbiosis environment,” clarifying that the sustainable operation of industry-education integration ecosystems depends on the coordinated evolution of these three dimensions[8]. Further research expanded this paradigm and illustrated the realization conditions for reciprocal symbiosis within the vocational-education industry-education

field[10].

Symbiosis theory enjoys high theoretical adaptability with municipal industry-education consortiums. Firstly, participating agents inside consortiums including governments, colleges, enterprises and research institutes constitute independent symbiosis units, whose heterogeneous interest demands and functional positioning serve as both the foundation for collaboration and sources of conflicts. Secondly, resource exchange, joint talent cultivation and co-research of technologies form core symbiosis relationships, and the closeness of symbiosis directly determines the comprehensive effectiveness of consortiums in education and innovation. Thirdly, consortiums are embedded in regional policy systems, industrial markets and institutional cultures that jointly constitute the symbiosis environment. The completeness of policies, maturity of markets and inclusiveness of institutions determine the development space of consortiums. From the symbiosis perspective, the implementation effect of practical-education functions is equivalent to the evolution level of each symbiosis unit from nominal agglomeration to substantive integration and from shallow symbiosis to deep symbiosis.

2.3. Three-dimensional Analytical Framework of “Organizational Form-Operational Contradictions-Resolution Paths”

Based on the above-mentioned two theoretical tools, this paper constructs an integrated three-dimensional analytical framework. The organizational-form dimension focuses on the governance structure and operational carriers of consortiums and responds to the core question of “what organizational system undertakes practical education”. The operational-contradiction dimension identifies structural tensions and deep-seated incentives in consortium operation combining organizational boundary theory and symbiosis theory. The resolution-path dimension puts forward adaptive optimization strategies targeting practical defects in organizational structures. The internal logic of the framework is as follows: organizational forms act as institutional carriers for practical-education implementation; boundary conflicts constitute core cruxes hindering educational-function delivery; symbiotic-governance paths represent practical schemes for resolving contradictions and activating educational effectiveness. The three components jointly form a complete analytical chain of “institutional design-practical dilemmas-optimization strategies”, which avoids superficial research merely describing organizational phenomena and breaks the limitation of fragmented countermeasure proposals, thus realizing organic unification of theoretical deduction and practical countermeasures.

Analytical thinking on complex-system governance conceptualizes municipal industry-education consortiums as cross-border complex systems that integrate education and industry. Rather than attributing contradictions simply to the subjective deficiencies of individual agents, this framework explains obstacles to practical-education functions from an organizational-institutional perspective[11].

3. Organizational Forms of Municipal Industry-Education Consortiums: Structural Characteristics and Educational-Support Logic

Based on investigations into multiple national-level pilot

cases of municipal industry-education consortiums, mature consortiums adopt an organizational system combining hierarchical governance structures and dual operational carriers, which provides structural support for the full-process implementation of practical education.

3.1. Governance Structure: Three-level Hierarchical System of “Council-Specialized Committee-Operation and Management Center”

Benchmark municipal industry-education consortiums in China generally build a closed-loop three-level governance structure: “top-level decision-making by councils, professional consultation by specialized committees and regular implementation by operation and management centers”, with clear power-responsibility hierarchies and explicit division of labor.

Council: Supreme Decision-making Hub

A council consists of representatives from local government competent departments, leading enterprises, vocational colleges and research platforms. It coordinates major issues including medium- and long-term development plans of consortiums, approval of key projects and formulation of internal management systems. The Jinan Intelligent Manufacturing and High-end Equipment Municipal Industry-Education Consortium expands into a four-level system of “council + operating entity + specialized committees + operation center” on the basis of the three-level framework, and sets up seven specialized committees covering intelligent equipment, artificial intelligence, new energy and intellectual property rights to realize precise docking of talent demands in segmented industries. The consortium led by Tangshan Polytechnic College builds a governance model of “one council and five departments”, establishing five physical functional departments for policy research, collaborative education, employment services, industrial development and training-base construction to form a complete governance closed-loop of decision-making, implementation and feedback. According to Zhang Jian’s (2024) sorting of national samples of municipal industry-education consortiums, a sound multi-agent council system serves as a prerequisite for consortiums to achieve substantive operation.

Specialized Committees: Specialized Collaborative Intermediaries

As professional hubs connecting decision-making and implementation layers, specialized committees undertake functions of policy consultation, project promotion and joint standard development divided by industrial tracks and business segments. The Yiwu Free-Trade Zone Municipal Industry-Education Consortium sets up special implementation working groups, industrial consulting institutions and segmented specialized committees to specifically address problems such as precise matching of regional industrial talent supply, technical training and industry-university-research transformation, and promote consortium governance from extensive overall planning to refined categorized governance.

Operation and Management Center: Daily Implementation Carrier

The operation and management center (permanent secretariat) undertakes regular work including resource

coordination, project management and inter-agent communication, addressing the short-term drawback of “emphasis on signing agreements yet neglect of operation and maintenance” in traditional university-enterprise cooperation. The Yiwu Consortium innovates a supporting mechanism of “one-case-one-policy and special funds for special purposes”. Member entities may apply for special industry-education projects as needed, and special funds will be allocated upon review by working groups, so as to realize rapid response to educational demands and precise allocation of resources.

3.2. Operational Carriers: Dual Implementation Logic of Platform-based Organizations and Project-oriented Operation

Municipal industry-education consortiums deliver educational work relying on two types of carriers, forming a dual-track operation mode where platforms aggregate resources and projects implement tasks.

Platform-based Organizations: Resource-aggregation Carriers in Both Physical and Institutional Dimensions

As open resource-integration platforms, consortiums do not directly engage in production-and-operation or independent teaching. Instead, they activate multi-agent collaborative potential by constructing hardware and software carriers. Physical platforms include shared training bases, industry-education integrated factories and industrial-technology research institutes. Institutional platforms cover soft mechanisms such as industry-education information-docking systems, co-construction platforms for talent-training standards and markets for transformation of technological achievements. Tangshan Polytechnic College jointly built customized shared manufacturing factories for robots, pooling over RMB 46 million of construction funds to equip 39 high-level training bases and 1 230 practical-training posts, building an integrated physical sharing platform for “teaching, production, research and service”. Drawing on provincial-level science-and-technology market standards, Jinan Vocational College built an on-campus industry-university-research service platform that connects the whole chain of technology R&D, teaching transformation and enterprise application, shortening the cycle for new technologies to be integrated into practical teaching.

Project-oriented Operation: Flexible Implementation Hand for Delivering Educational Tasks

Various collaborative-education and technology-research tasks are advanced in the form of independent projects. Compared with fixed institutional cooperation, it boasts three institutional advantages. First, dynamic adaptability: educational contents can be flexibly adjusted along with industrial-technology iteration and changes in post demands. Second, quantifiable assessment: standardized evaluation indicators can be established for project outputs and talent-training outcomes to improve the overall performance-evaluation system of consortiums. Third, long-term incentives: contribution-point and performance-subsidy linkage mechanisms can be built based on projects to tackle the deficiency of incentives in traditional cooperation. Jinan Vocational College implemented the “contribution-point” incentive system, linking the participation of enterprises and colleges in projects with policy support and resource access rights. The Yiwu Consortium adopted a project-driven model covering talent cultivation, mutual appointment of teachers, technology R&D

and continuing education, providing definite implementation carriers for all practical-education work.

3.3. Three-dimensional Structural Support of Organizational Forms for Practical Education

The above-mentioned governance structures and operational carriers guarantee the sustainable implementation of practical-education functions from the dimensions of overall planning, hardware facilities and driving forces.

First, hierarchical governance structures realize overall planning of educational work. Councils anchor directions of regional industrial development to ensure top-level design of talent cultivation fits industrial demands; specialized committees match post standards of segmented industries to improve the industrial adaptability of practical teaching; operation and management centers follow up the whole process of educational projects continuously and avoid episodic and campaign-style cooperation drawbacks.

Second, physical sharing platforms make up for hardware deficiencies in practical teaching. Shared factories and industry-education training bases as well as on-campus factories build authentic production-and-teaching scenarios, transforming teaching modes from simulated training to productive practice. Cooperating with leading enterprises such as China National Heavy Duty Truck Group and Jinan No. 2 Machine Tool Works, Jinan Vocational College built on-campus production workshops, fully introducing enterprise production lines and industrial management norms, constructing an integrated practical system of “on-campus production training+enterprise on-the-job internship” to facilitate students’ identity transition from learners to quasi-industrial employees.

Third, project-oriented mechanisms activate endogenous driving forces for enterprises to participate in collaborative education. Special projects including order-form classes and on-site-engineer training push enterprises to deeply participate in revision of talent-training schemes, development of curriculum standards and practical-teaching cases, integrating new technologies, crafts and specifications into daily teaching. Enterprises obtain talents matching post demands directly through targeted projects and shift from passively participating due to policy requirements to actively engaging in collaborative education, addressing the structural contradiction of “enthusiastic colleges yet cold enterprises”. As pointed out by Cao Ye (2023), the project-based system can effectively reduce institutional transaction costs of cross-border cooperation and fits municipal-level industry-education collaboration scenarios.

4. Operational Contradictions of Municipal Industry-Education Consortiums: Structural Tensions of Three Organizational Boundaries

Despite the inherent advantages of consortium organizational structures for collaborative education, pilot projects across regions generally suffer from insufficient release of practical-education effectiveness. Drawing on organizational boundary theory, operational obstacles can be generalized into contradictions of physical, social and psychological boundaries, whose underlying root lies in conflicts of institutional logic.

4.1. Solidified Physical Boundaries:

Blocked Integration and Circulation of Cross-domain Resources

Physical boundaries denote tangible segmentation formed by geographical spaces, hardware facilities and industrial-technical standards of each agent. Their solidification gives rise to two core problems: high costs for resource sharing and mismatched supply-demand relations. First, spatial segmentation lowers the efficiency of training-resource sharing. Though built upon industrial parks, consortium members including colleges, enterprises and research institutes are physically isolated. Transfer costs for large precision training equipment across agents remain high. Training equipment in vocational colleges lags behind industrial-technology iteration, while high-end production equipment of enterprises faces constraints from production capacity and safety when opened for teaching. Insufficient popularization of virtual-simulation training bases further aggravates resource shortages. Second, heterogeneous technical standards between universities and enterprises raise teaching-adaptation costs. Systematic deviations exist between college teaching norms, curriculum technical parameters and actual enterprise production processes, resulting in “disconnection between classroom teaching and post practice”, extending students’ post-adaptation cycles and directly impairing practical-education effectiveness. Practices of Tangshan Polytechnic College prove that only independent substantive shared platforms can break shackles of physical boundaries. Nevertheless, large upfront investment for platform construction and imperfect long-term operation-maintenance systems remain common challenges.

4.2. Blurred Social Boundaries:

Fractured Multi-agent Collaborative-Education Chains

Social boundaries are constructed by agent power-responsibility, benefit distribution and cooperative institutions. Blurred boundaries directly trigger three practical plights: ambiguous power-responsibility, unbalanced benefits and fractured collaboration. First, power-responsibility division lacks institutional definition. Unified lists of power-responsibility, benefits and obligations for governments, enterprises, colleges and industry associations in practical education have not been formulated, rendering the “united yet not integrated” phenomenon commonplace in consortiums. According to surveys by Yu Li and Duan Jiayu (2026), most university-enterprise cooperation remains at superficial levels such as framework agreements and short-term internships, without establishing full-process collaborative-education mechanisms. Second, imbalanced benefit-distribution mechanisms weaken enterprises’ willingness to participate. There lacks quantitative accounting and fair-distribution systems for talent returns, policy subsidies and technical rewards corresponding to resources invested by enterprises including equipment, engineers and training posts. Enterprises participate in consortiums mostly out of external pressures such as policy assessment and social responsibilities rather than endogenously driven by economic returns, resulting in prominent imbalance between resource input and returns of symbiosis units. Third, full-chain collaborative mechanisms are absent. Practical education covers the complete chain of specialty setup, curriculum development, practical teaching and on-the-job employment. Agents perform duties segmentally without overall coordination, leading to structural fractures in the full-chain

collaborative-education system. Cognitive biases of each agent toward its own educational role make it difficult to form consistent educational resultant forces.

4.3. Conflicting Psychological Boundaries:

Fragile Foundation of Cross-agent Value Consensus

Psychological boundaries are rooted in organizational culture, value orientation and cooperation trust of organizations. Cultural divergences, goal discrepancies and lack of trust among different agents continuously intensify cooperative contradictions. Firstly, natural estrangement exists in organizational cultures. Colleges adhere to educational orientation focusing on all-round student development and basic-ability cultivation; enterprises follow production-efficiency orientation laying stress on cost control and capacity improvement. Remarkable divergences emerge between the two cultures in educational evaluation criteria and teaching implementation modes. Even after cooperation agreements are signed, conceptual frictions tend to occur in implementation phases and result in nominal cooperation. Secondly, value-goal demands differ significantly. Governments prioritize regional industrial upgrading and stable employment; colleges attach importance to talent-training quality and graduate employment rates; enterprises focus on labor costs and talent-post fitness. It is difficult to unify value orientations and evaluation criteria for “practical education” among all parties, leading to insufficient centripetal force for overall consortium actions. Thirdly, long-term cooperative trust has not been accumulated. Traditional industry-education integration is mostly short-term cooperation driven by administration, and collaborative relations dissolve once projects are completed. In-depth long-term trust between universities and enterprises is insufficient. Coupled with lagging policy supports and unbalanced industrial layout in some regions, inadequate symbiosis environments further amplify psychological-boundary conflicts.

4.4. Underlying Incentive: Heterogeneous-logic Game of Multi-agent Institutions

Contradictions among the three organizational boundaries are not merely management-operation problems. Their endogenous root lies in the fact that multi-agent participants belong to different fields and follow differentiated institutional logics, thus generating persistent structural games. Institutional-logic theory indicates that different social fields derive exclusive action norms and value-judgment systems. Governments follow bureaucratic administrative logic targeting policy implementation and balanced allocation of public resources; enterprises abide by market-operation logic with investment returns and market competitiveness as decision-making criteria; vocational colleges comply with educational-logic principles guided by talent growth and teaching rules; research institutes follow academic-innovation logic prioritizing technological breakthroughs and academic outputs.

The four types of institutional logics interweave and collide within the same collaborative field of consortiums, yet effective mediation and transformation mechanisms are absent, giving rise to three inherent contradictions. First, each agent cannot reach consensus on the value weight and evaluation criteria of practical education. Second, resource input and benefit returns fall under different accounting systems, making it hard to build cross-agent

equivalent-exchange rules. Third, consortium decisions cannot satisfy multiple-value demands including administrative equity, market efficiency and educational rules simultaneously. Therefore, contradictions in consortium operations feature endogeneity and long-term nature and cannot be fundamentally resolved merely by optimizing management measures. It is imperative to construct symbiotic-governance systems adaptive to diverse logics.

5. Resolution Paths: Building a Symbiotic Collaborative-Governance System for Municipal Industry-Education Consortia

To mitigate tensions of three organizational boundaries and reconcile conflicts in multi-agent institutional logics, the core approach is to construct symbiotic collaborative-governance mechanisms: eliminate physical boundaries through substantive operation, straighten out inter-agent relations via benefit coupling, bridge cognitive gaps with digital technologies, and realize the transformation of consortium driving forces from external administrative impetus to endogenous empowerment of the industry-education ecosystem.

5.1. Substantive Operation: Consolidating Institutional Foundations for Cross-border Collaboration

Substantive operation serves as the basic institutional guarantee for consortiums to evolve from loose alliance to deep symbiosis. Its core is to endow consortiums with independent operational-subject qualifications, stable fund supports and standardized governance institutions.

First, clarify qualifications for independent operation of consortiums. At present, most consortiums lack independent legal-person qualifications, which creates institutional barriers in resource integration, contract signing, property-right division and fund management. Pilots can be carried out to register municipal industry-education consortiums as private non-enterprise entities or non-profit social organizations to obtain independent civil-juristic-act capacities and guarantee independent operation from the legal perspective. As Jiang Dayuan (2023) pointed out, the absence of legal-person subjects constitutes the most critical institutional bottleneck restricting substantive operation of municipal industry-education consortiums. Yiwu allocates RMB 5 million of special funds for consortiums annually for six consecutive years, superimposed with supporting funds for talents, infrastructure and school-running to build a sustainable fund-guarantee mechanism worthy of nationwide promotion.

Second, improve hierarchical checks-and-balances governance closed-loops. On the basis of existing three-level structures, formulate power-responsibility lists for each tier and set up independent supervision institutions to form a governance system of “council for decision-making, operation center for implementation and third-party institutions for supervision” with mutual checks-and-balances, avoiding empty power-responsibility and disordered decision-making. The modular functional structure of “one council and five departments” adopted by Tangshan Polytechnic College provides practical models for standardized governance of consortiums.

Third, perfect long-term incentive supporting systems.

Formulate consortium charters, project-management measures and member-assessment rules, and innovate contribution-point incentive systems linking enterprises’ educational-participation effectiveness with tax reductions, special subsidies and industrial-support credits. Zhuzhou in Hunan province set up industry-education integration venture-capital funds and special-agent subsidies, disbursing over RMB 9 million of supporting funds in total and effectively promoting transition from loose collaboration to close symbiosis.

5.2. Benefit Coupling: Activating Endogenous Driving Forces of Symbiosis Units for Collaborative Education

Benefit coupling acts as a core lever for reconciling conflicts in multi-agent institutional logics. It is necessary to build a balanced distribution system of “risk sharing and benefit sharing” and convert externally-driven administrative cooperation into endogenous cooperation demands of each agent.

First, establish quantitative co-construction-and-sharing distribution mechanisms for resources. Formulate resource-value-evaluation standards for consortiums to quantitatively calculate inputs including college teachers, training venues, enterprise equipment and technical patents. Resource-contribution points shall be directly linked with project priority, benefit-distribution ratios and policy-support quotas to realize positive incentives for more input and more feedback. Relying on digital supply-demand adaptation platforms, Jinan Vocational College achieves precise calculation of resource input and benefit distribution and greatly reduces cross-agent benefit-coordination costs.

Second, deepen comprehensive educational reforms integrating posts, courses, competitions and certificates. Integrate enterprise post standards, college curriculum systems, skill-competition norms and vocational-qualification-assessment contents to build a closed-loop education mode of “curriculum design oriented by posts, training promoted by competitions and competence evaluated by certificates”. Supported by order-form classes and targeted on-site-engineer training projects, enterprises participate in the whole talent-cultivation process, realizing the matching of students with posts upon enrollment and direct employment after graduation, and directly satisfying enterprises’ demands for precise talent recruitment.

Third, implement the collaborative-research mode of “enterprises putting forward problems, colleges tackling problems and markets conducting inspections”. Appropriately increase the proportion of industry-university-research project funds within consortiums and build an integrated linkage mechanism for R&D, teaching and transformation. The Yiwu Consortium raises the proportion of special scientific-research funds to 40 %. It carries out research projects centering on real technical bottlenecks of enterprises, which not only helps enterprises overcome production obstacles, but also provides authentic practical-teaching projects for colleges, realizing two-way empowerment of industrial innovation and practical education.

5.3. Digital Empowerment: Comprehensively Penetrating Organizational Boundaries with Technological Means

Digital technologies can reduce cross-agent information asymmetry and communication costs, and weaken constraints of physical, social and psychological boundaries from the technical dimension.

First, build a municipal integrated smart-management platform for industry-education. Integrate functional modules covering enterprise post demands, college specialty resources, university-enterprise cooperation projects and mutual-appointment information of teachers to realize dynamic updating of industrial-talent demands and intelligent matching of educational projects, and reduce frictions in supply-demand docking. According to Xu Guoqing (2024), digital platforms can reshape resource-allocation modes for industry-education integration and break information-island dilemmas. The intelligent industry-education adaptation platform of Jinan Vocational College sets up five core business systems to realize forward-looking judgment of regional talent demands and improve the precision of talent cultivation.

Second, build a hybrid practical-teaching system combining online training and offline practice. Carry out remote theoretical teaching and skill preview relying on virtual-simulation training platforms, and complete practical training on offline shared bases to resolve work-study contradictions for on-the-job enterprise employees and on-campus students, expanding the coverage of practical education delivered by consortiums.

Third, apply big-data technologies to dynamically predict regional industrial-talent demands. Monitor changes in regional industrial scale, technology iteration and post gaps in real time to guide colleges to dynamically adjust specialty layouts and update practical-teaching contents, fundamentally mitigating structural mismatches between talent cultivation and industrial demands.

5.4. Transformation of Governance Modes: From Administrative Promotion to Ecological Empowerment

The ultimate goal of substantive operation, benefit coupling and digital empowerment is to realize fundamental transformation of consortium governance modes, redefine functional orientations of governments, colleges and enterprises, and construct a multi-governance industry-education symbiosis ecosystem.

First, governments: transform from administrative dominators to ecological enablers. Governments shall weaken direct-control functions and focus on institutional supply, policy support and environment construction: formulate local industry-education integration-support regulations and improve fiscal, tax and financial incentive policies; introduce third-party assessment institutions, incorporate enterprises' educational investment, student-employment fitness and technology-transformation benefits into consortium assessments, and link assessment results with special-fund allocation to "steer instead of oar".

Second, vocational colleges: transform from passive cooperators to leaders in industrial services. Strengthen core functions of colleges in serving regional industries and establish dynamic specialty-adjustment mechanisms; enforce mandatory requirements for professional teachers to practice

in enterprises regularly, incorporate front-line enterprise-practice experience into core indicators for professional-title evaluation, and continuously improve teachers' practical-teaching capabilities; take the initiative to connect leading industrial enterprises and attract in-depth enterprise participation via high-quality talent supply and technical services.

Third, enterprises: transform from marginal participants to embedded ecological subjects. Implement the two-way talent-flow system between universities and enterprises, set up on-campus teaching posts for enterprise engineers and enterprise R&D posts for college teachers; encourage enterprises to set up enterprise studios and industrial-R&D centers within consortiums, realizing enterprises' role upgrading from merely providing training posts to collaborative education and joint construction of industrial ecosystems.

6. Conclusion

Municipal industry-education consortiums constitute key institutional innovations for tackling superficial-collaboration dilemmas in industry-education integration. Their core transformative logic lies in promoting the transition of practical education from traditional loose university-enterprise connections to multi-agent substantive symbiosis through organizational-system reconstruction. Integrating organizational boundary theory and symbiosis theory, this paper constructs a unified analytical framework of "organizational form-operational contradictions-resolution paths" and systematically interprets the realization mechanism of practical-education functions of consortiums. Three core conclusions are drawn. First, municipal industry-education consortiums have formed stable and mature organizational-operation systems: vertically establishing the three-level governance structure of "council-specialized committee-operation and management center", and horizontally adopting the dual-track operation mode of platform-based carriers and project-oriented mechanisms. This organizational system provides structural guarantees for full-process practical-education implementation from the dimensions of overall coordination, hardware support and motivation incentives. Second, three structural tensions of organizational boundaries persist in consortium operations: solidified physical boundaries restrict cross-domain resource integration; blurred social boundaries fracture collaborative-education chains; conflicting psychological boundaries erode cooperative value consensus. Rather than superficial management problems, the above-mentioned contradictions are rooted in heterogeneous-logic games among governments, colleges, enterprises and research institutes, and feature endogeneity and persistence. Third, the core solution to resolve boundary contradictions and release practical-education effectiveness is to build symbiotic-governance systems: improve institutional frameworks via substantive operation, reconcile agent demands through benefit coupling, eliminate cross-border barriers with digital technologies, and finally realize the transformation of consortium governance modes from externally-driven administrative impetus to endogenous empowerment of the industry-education symbiosis ecosystem, thus promoting consortiums to evolve from policy-pilot carriers into sustainably-operated organic bodies of industry-education integration ecosystems.

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