

Innovative Collaborative Education Model of Modern Industrial Colleges from the Perspective of Government-University-Enterprise Synergy—A Case Study of the Intelligent Equipment Industrial College

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Abstract: This study examines the innovation of a collaborative education model in modern industrial colleges from the perspective of government-university-enterprise synergy, using the Intelligent Equipment Industrial College of Qiqihar University as a case. Guided by synergy theory, educational ecosystem theory, and the Outcome-Based Education (OBE) framework, the research constructs a three-level analytical model covering system governance, curriculum integration, and outcome evaluation. Data were collected through institutional documents, interviews, and performance records from 2022 to 2024. The results show that the Council-led governance mechanism, dual-mentor teaching system, and project-based learning significantly improve students' engineering competence and employment relevance. The synergy among government, university, and enterprise stakeholders enhances curriculum quality, promotes research-industry collaboration, and strengthens regional innovation capacity. The findings suggest that institutionalized cooperation and competence-based evaluation are key to sustaining the modernization of application-oriented higher education in China.

Keywords: Collaborative Education, Industry-Education Integration, Modern Industrial College; Government-University-Enterprise Synergy

1. Introduction

The modernization of higher education in China requires a deeper connection between education and industry. The Guidelines for the Construction of Modern Industrial Colleges (Trial) issued by the Ministry of Education in 2021 encourage the establishment of multi-party cooperation among government, universities, and enterprises to improve the match between talent training and industrial transformation^[1].

Heilongjiang Province, a traditional manufacturing base, faces pressure to upgrade its intelligent equipment and mechanical engineering sectors. Local enterprises need engineers who can manage automation, digital manufacturing, and system integration, while universities must reform curricula and pedagogy to meet these skill demands^[2].

The gap between academic preparation and industrial application highlights the need for an institutionalized collaborative education mechanism. To address this challenge, Qiqihar University founded the Intelligent Equipment Industrial College, supported by the Heilongjiang Provincial Department of Education and enterprises such as Qizhong CNC Equipment Co., Ltd. and the Qiqihar High-Tech Development Zone. The college adopts a government-university-enterprise synergy mechanism that combines joint governance, co-developed curricula, dual-mentor instruction, and project-based learning.

Unlike conventional school-enterprise partnerships, which rely mainly on internships, this model builds a long-term framework linking policy guidance, academic innovation, and enterprise participation. Government agencies provide strategic direction and funding; the university coordinates teaching and research; and enterprises contribute real projects, technologies, and evaluation feedback.

This study takes the Intelligent Equipment Industrial College as a case to examine how a collaborative education model can operate within a regional application-oriented university. It analyzes the model's

governance structure, curriculum integration, and implementation outcomes, providing evidence for how government-university-enterprise synergy supports competency-based engineering education in the context of industrial upgrading^[3].

2. Research Framework and Methodology

This study adopts a qualitative case study approach to analyze the construction and operation of the collaborative education model at the Intelligent Equipment Industrial College of Qiqihar University. The analytical framework integrates synergy theory, educational ecosystem theory, and the Outcome-Based Education (OBE) paradigm, providing a multidimensional perspective on how government-university-enterprise cooperation enhances the effectiveness of application-oriented higher education.

According to synergy theory, sustainable systems depend on the coordinated operation of multiple subsystems sharing common objectives. In this context, governments, universities, and enterprises act as interdependent subsystems that co-produce educational value. The government provides policy direction and supervision; universities manage teaching, research, and quality assurance; enterprises contribute industrial resources, technical expertise, and real projects. Through shared goals and feedback mechanisms, these entities form a self-regulating education system.

The educational ecosystem theory expands this concept by viewing higher education as an open and adaptive network. The Intelligent Equipment Industrial College functions as such an ecosystem—integrating knowledge creation, skill cultivation, and technological application. Each actor assumes a distinct yet complementary role: government ensures the institutional environment, universities drive pedagogical innovation, and enterprises anchor industrial relevance. This multi-actor collaboration maintains the dynamic flow of resources, information, and innovation across organizational boundaries.

At the teaching level, the OBE framework provides operational guidance. It emphasizes output-based learning and competency alignment rather than input-oriented processes. Curriculum objectives, teaching design, and assessment standards are directly mapped to enterprise job profiles and professional qualifications. This alignment ensures that graduates' abilities correspond to actual industrial requirements, transforming learning outcomes into measurable performance indicators.

2.1. Analytical Framework

Based on these theoretical foundations, the study constructs a three-level analytical framework:

- (1) System Level—governance and decision-making structures;
- (2) Curriculum Level—co-developed programs and dual-mentor mechanisms;
- (3) Outcome Level—talent cultivation quality and innovation performance.

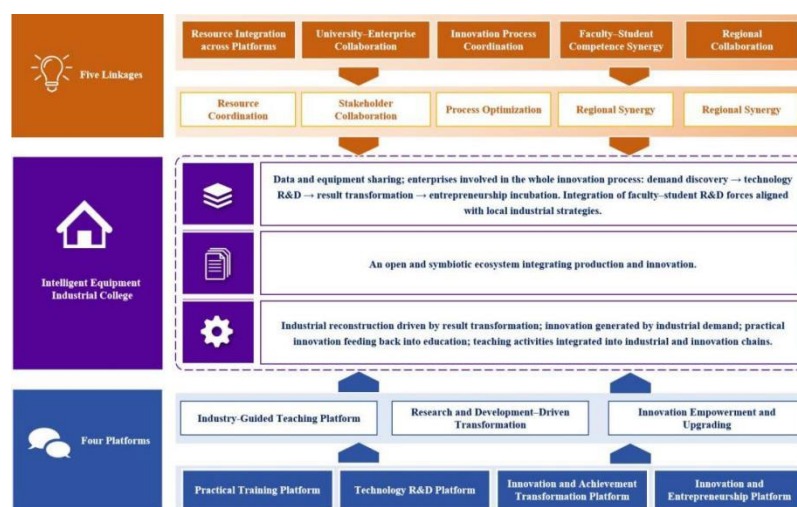


Figure 1: The “Four Platforms and Five Linkages” Framework of the Intelligent Equipment Industrial College

As shown in Figure 1, the “Four Platforms and Five Linkages” framework connects policy, teaching,

practice, and innovation processes into a unified collaborative mechanism, illustrating the structural logic of the Intelligent Equipment Industrial College.

2.2. Data Sources and Methods

Data were collected from 2022 to 2024 through three channels:

(1) Institutional Documents and Reports: including the Three-Year Construction Plan of the Intelligent Equipment Industrial College (2025–2027) and the Heilongjiang Provincial Higher Education Teaching Achievement Report (2025).

(2) Interviews and Field Observations: semi-structured interviews with administrators, faculty, and enterprise mentors were conducted to understand governance practices and collaboration effects.

(3) Quantitative and Qualitative Outcomes: student participation, competition results, and employment statistics were analyzed to evaluate implementation effectiveness.

All materials were examined through thematic analysis and cross-case triangulation, ensuring consistency among document, interview, and performance data. The research follows the process of “problem identification → mechanism construction → implementation analysis → outcome evaluation,” aligning with the exploratory nature of educational reform research.

3. Implementation of the Collaborative Education Model

The collaborative education model of the Intelligent Equipment Industrial College of Qiqihar University was designed to align government policy, university resources, and enterprise participation into an integrated mechanism of co-governance, co-teaching, and co-evaluation. The implementation process involves three major components: governance and organization, curriculum and dual-mentor collaboration, and practice-oriented innovation platforms.

3.1. Governance Structure and Organizational Mechanism

The college operates under a Council-led, Dean-responsible governance model, forming a multi-layered coordination system that connects government, university, and enterprise decision-making. The Council consists of representatives from the Heilongjiang Provincial Department of Education, Qiqihar High-Tech Development Zone, Qizhong CNC Equipment Co., Ltd., and the university’s administrative offices. It oversees strategic planning, policy implementation, and performance evaluation.

Beneath the Council, an Executive Committee manages operational affairs, including curriculum approval, faculty development, and enterprise collaboration. Specialized subcommittees—covering teaching, research, and project management—ensure that cooperation is embedded in every functional level. For example, curriculum decisions must be jointly reviewed by both academic and industrial experts, ensuring that educational design corresponds with current industrial technology standards.

The Charter of the Intelligent Equipment Industrial College defines clear responsibilities among stakeholders:

Government: provides policy guidance, funding incentives, and quality supervision;

University: focuses on curriculum design, talent cultivation, and quality assurance;

Enterprise: contributes industrial projects, technical mentoring, and training bases.

This structure enables the transformation of short-term cooperation into a long-term, institutionalized partnership that balances educational and industrial interests^[4].

3.2. Curriculum Co-Development and Dual-Mentor Teaching

Curriculum reform forms the core of the collaborative model. Based on the OBE framework, Qiqihar University restructured its program into three progressive learning stages: fundamental knowledge acquisition, professional skill development, and innovation capability enhancement.

At the foundational stage, general engineering courses are jointly designed by university professors and enterprise engineers. Industrial cases and production scenarios are embedded in classroom teaching to strengthen contextual learning. At the professional stage, project-based learning (PBL) modules

connect students directly with real enterprise projects, such as CNC automation and intelligent manufacturing systems. As illustrated in Figure 2, the “dual-channel and triple-synchronization” model links on-campus study with enterprise practice through synchronized learning goals, processes, and assessments^[5].

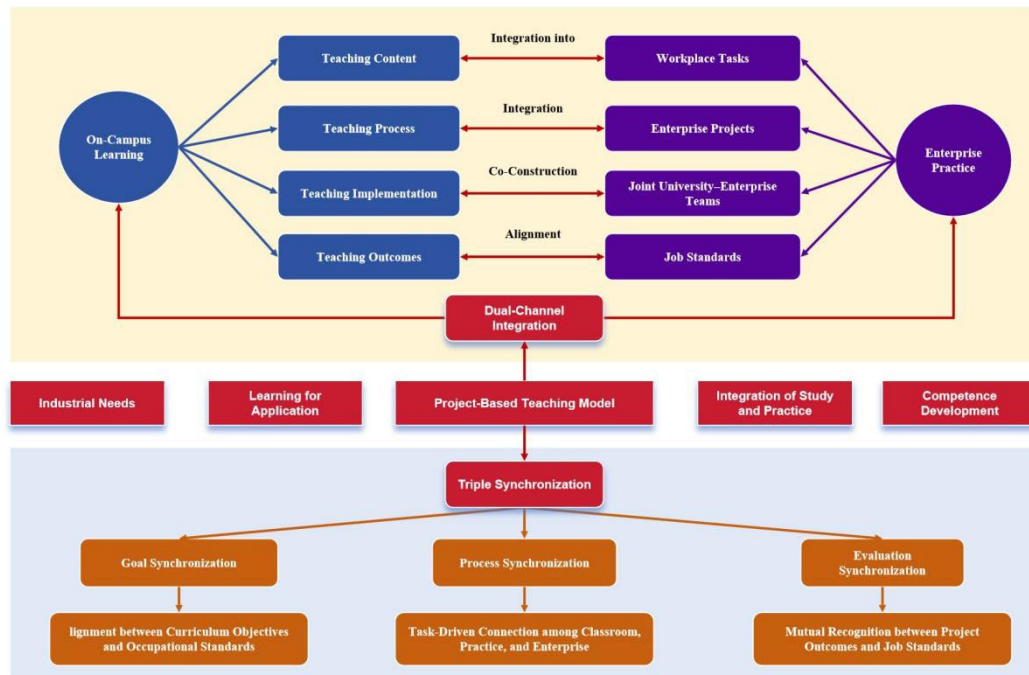


Figure 2: The Dual-Channel and Triple-Synchronization Project-Based Teaching Model

The dual-mentor system complements this structure. Each student is assigned two mentors—an academic mentor guiding theoretical study and an enterprise mentor supervising practice and innovation. Learning objectives, tasks, and evaluations are co-defined by both mentors, ensuring alignment between academic learning and job competencies.

Table 1 summarizes the collaborative curriculum framework, showing the relationship among learning stages, teaching activities, and industry engagement.

The integration of these mechanisms ensures that knowledge acquisition, skill training, and innovation are seamlessly connected throughout the learning process.

Table 1: Collaborative Curriculum Framework of the Intelligent Equipment Industrial College

Learning Stage	Main Teaching Form	Enterprise Participation	Expected Competence
Basic Knowledge	Joint theoretical courses	Industrial case lectures	Engineering fundamentals
Professional Skills	Project-based learning (PBL)	Real enterprise projects	Technical application
Innovation Practice	Research and competition projects	Dual-mentor supervision	Innovation and teamwork

3.3. Practice Platforms and Innovation Ecosystem

To support collaborative teaching and research, the college and its enterprise partners have co-constructed a multi-level practice ecosystem that combines on-campus laboratories, off-campus training bases, and industrial R&D centers. The 2,000-square-meter Joint Intelligent Manufacturing Training Base houses robotic arms, digital twin systems, and industrial Internet equipment. Students participate in real-time production simulations, gaining practical experience in process design, system debugging, and equipment operation.

At the same time, collaboration with the Heilongjiang Intelligent Machine Tool Research Institute enables joint R&D and technology transfer projects. Over the past three years, the college has completed 40 enterprise innovation projects and 15 technology service contracts, resulting in tangible outputs such as patents, software systems, and prototype machines. These achievements demonstrate the integration

of education, research, and industry^[6].

The “Four Platforms and Five Linkages” mechanism (see Figure 1) operates as the backbone of this ecosystem, connecting teaching, research, innovation, and industry upgrading. The four platforms—teaching-training integration, technology R&D, results transformation, and innovation incubation—are supported by five linkages across resources, subjects, processes, competencies, and regions. This structure promotes sustainable collaboration among different stakeholders.

To monitor and evaluate outcomes, the college established a Collaborative Education Evaluation System, using data from enterprise feedback, student performance, and project achievements. The results of recent years are summarized in Table 2.

Table 2: Key Quantitative Outcomes of the Collaborative Education Model (2022–2024)

Indicator	2022	2023	2024
Student participation in enterprise projects (%)	48	55	62
Employment in related industries (%)	68	73	77
Innovation & entrepreneurship awards	68	92	96
Enterprise research collaborations	12	19	24
Jointly developed courses	15	20	21

As shown in Table 2, student participation, industry employment, and innovation achievements have improved steadily over three years, demonstrating the effectiveness of the synergy-based education system.

3.4. Summary

The implementation of the collaborative model at Qiqihar University demonstrates a systematic alignment between institutional governance, curriculum reform, and industrial practice. Through co-governance, co-teaching, and co-evaluation, the Intelligent Equipment Industrial College has established a self-reinforcing mechanism that bridges the gap between academia and industry. The combination of Figure 1, Figure 2, and the two tables provides a visual and quantitative illustration of this process, confirming that the government-university-enterprise synergy effectively enhances talent quality, teaching innovation, and regional industrial upgrading.

4. Findings and Discussion

The implementation results of the collaborative education model at the Intelligent Equipment Industrial College demonstrate substantial progress in aligning higher education with industrial needs. This section discusses the model’s outcomes from three dimensions: talent cultivation quality, teaching and research enhancement, and institutional sustainability. Evidence is drawn from Table 2 and interview data, supported by continuous performance tracking from 2022 to 2024.

4.1. Improvement in Talent Cultivation Quality

As shown in Table 2, student participation in enterprise projects increased from 48 % in 2022 to 62 % in 2024. This steady growth indicates a structural shift from classroom-centered to project-based learning. Students now engage in industrial design, system debugging, and data-driven optimization tasks under real production conditions. More than 70 % of graduates have secured employment in intelligent manufacturing and automation sectors, with a job-major match rate exceeding 85 %.

Interviews reveal that both faculty and enterprise mentors view the dual-mentor system as the most effective component of the model. Enterprise mentors guide students through authentic production challenges, while academic mentors ensure theoretical rigor. This dual supervision not only strengthens professional competencies but also cultivates teamwork, communication, and innovation skills—key indicators of employability in engineering fields.

4.2. Enhancement of Teaching and Research Capacity

The collaborative model also contributes to institutional improvement. Faculty members actively participate in enterprise R&D, bridging academic research with technological innovation. Between 2022 and 2024, 26 enterprise engineers were appointed as adjunct instructors, while 58 university teachers

engaged in enterprise-based research projects. This mutual exchange expands the teaching team's engineering literacy and refreshes course content with up-to-date industrial technologies.

Joint research activities have yielded tangible results: 14 co-authored textbooks, 21 enterprise-developed courses, and 15 technology transfer projects covering areas such as digital twin design and robotics control. These achievements reflect a deep integration of teaching, research, and industry. The Outcome-Based Education (OBE) framework ensures that each course outcome is aligned with industrial competency standards, allowing universities to evaluate student learning using performance-based criteria rather than rote examination.

4.3. Institutionalization and Governance Impact

The Council-led governance system ensures balanced decision-making among government, university, and enterprise representatives. Unlike traditional administrative management, this mechanism links strategic goals with operational performance through a feedback loop. The introduction of the Performance Evaluation and Incentive Policy for Modern Industrial Colleges has created measurable indicators for collaboration, including the number of co-developed courses, enterprise projects, and student competitions.

Such governance innovation promotes accountability and continuity. Enterprises gain access to talent pipelines and research resources, while universities receive industrial funding and real-world feedback to refine curricula. Government agencies, in turn, use the evaluation data to allocate policy incentives, forming a self-reinforcing governance ecosystem. The experience of Qiqihar University has already been recognized by the Heilongjiang Provincial Department of Education as a benchmark for regional industrial-education integration.

4.4. Discussion

The findings demonstrate that government-university-enterprise synergy transforms education from a closed academic process into an open, innovation-driven ecosystem. Compared with conventional cooperation models, the institutionalized approach of the Intelligent Equipment Industrial College produces more sustainable and measurable results. Three lessons emerge:

Long-term Mechanisms Outperform Short-term Projects. Institutionalized governance and performance evaluation maintain collaboration beyond individual programs or personnel changes.

Competence-based Curriculum Is Essential. Aligning learning outcomes with enterprise job standards ensures that students acquire directly transferable professional skills.

Mutual Benefit Drives Sustainability. When all actors—government, universities, and enterprises—gain tangible value from cooperation, the partnership becomes self-sustaining.

Overall, the Qiqihar case provides empirical evidence that the modernization of industrial colleges requires systemic coordination across multiple levels—policy, institution, curriculum, and evaluation. The collaborative model thus contributes not only to talent development but also to regional industrial upgrading and innovation capacity.

5. Conclusion and Implications

The case of the Intelligent Equipment Industrial College at Qiqihar University demonstrates that a government-university-enterprise collaborative education model can effectively bridge the gap between academic training and industrial application. By institutionalizing cooperation through a Council-led governance system, the college transforms short-term collaboration into a long-term mechanism for continuous improvement. The integration of policy guidance, curricular reform, and enterprise participation ensures that education, talent cultivation, and industrial development evolve in coordination.

At the operational level, the implementation of outcome-based curricula, dual-mentor teaching, and project-based learning enables students to acquire industry-aligned competencies. Quantitative results—including increased student participation in enterprise projects, higher employment relevance, and growing research outputs—verify the practical value of this model. Moreover, the establishment of practice platforms and innovation ecosystems reinforces the alignment between teaching, research, and technological transformation.

From a policy perspective, the Qiqihar model offers a replicable pathway for regional application-oriented universities seeking to modernize their educational structures. It highlights three key implications:

- (1) Institutionalization of collaboration is essential for sustainability;
- (2) Competence-based teaching and evaluation ensure alignment with industrial needs;
- (3) Mutual benefit among stakeholders strengthens long-term engagement.

As China advances its industrial upgrading agenda, the synergy between government, universities, and enterprises will remain a cornerstone of higher education modernization. The experience of Qiqihar University thus provides both theoretical insight and practical evidence for the future development of modern industrial colleges.

Acknowledgements

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