

Building a “Theoretical and Practical Dual-Qualified” Teacher Team of Sino-Foreign Cooperative Education in Mechanical Engineering: Practical Challenges and Collaborative Development Mechanisms

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Abstract: Against the backdrop of intensifying global industrial upgrading and technological competition, the development of a “theoretical and practical dual-qualified” teaching faculty in mechanical engineering Sino-foreign cooperative education programs undertakes the critical mission of cultivating high-level international engineering talent. This holds significant practical importance for both industrial advancement and talent development. Currently, the development of such faculty faces three core bottlenecks: insufficient supply of teacher competencies, outdated practical teaching content, and inadequate industry-education collaboration mechanisms. A systematic reconstruction is proposed across three dimensions: individual teachers, institutional organizations, and industry-institution collaboration, which establishes an individual career pathway based on “technical portfolios,” organizational transformation centered on “teaching innovation teams,” and a practical community characterized by “role integration.” Ultimately, this paper aims to construct a collaborative governance ecosystem involving “government, industry, institutions, and enterprises” in a quadrilateral linkage. This ecosystem, guided by government policies and industry standards, with deep participation from both educational institutions and enterprises, will systematically promote the sustainable cultivation of “Theoretical and practical dual-qualified” teachers and support the high-quality development of mechanical engineering Sino-foreign cooperative education programs.

Keywords: “Theoretical and practical dual-qualified” teachers; Mechanical engineering; Sino-foreign cooperative education programs; Industry-education integration

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1. Introduction

Amidst the intensifying global industrial upgrading and technological competition, the internationalization of higher engineering education has emerged as a core strategic pathway for nations to enhance their technological innovation capabilities and cultivate high-end engineering talent. As one key institutional carrier of Chinese educational opening-up, Sino-foreign cooperative education undertakes multiple critical missions, particularly in engineering fields such as mechanical engineering that underpin the national industrial system. In recent years, national policy has consistently emphasized and sought to deepen the development of “theoretical and practical dual-qualified” teaching faculties. The core requirement for such teachers is to possess both solid theoretical pedagogical proficiency and outstanding practical instructional ability. For mechanical engineering Sino-foreign cooperative programs, qualified “theoretical and practical dual-qualified” teachers must not only master advanced engineering theory and professional practical skills but also be capable of instructional design in cross-cultural contexts. They need familiarity with both Chinese and foreign educational systems, and the ability to integrate international engineering practices with localized teaching environments. Notably, the recent paradigm shift in manufacturing centered on smart manufacturing has established new benchmarks for the competency structure of engineering talent.

In this context, as a vital platform for cultivating internationally oriented innovative talent, the development of “theoretical and practical dual-qualified” teachers in mechanical engineering cooperative programs hinges on moving beyond a simple combination of theory and practice. Instead, it requires constructing an educational philosophy that deeply integrates new engineering concepts from both China and abroad. Whether such an integrated philosophy can be established is not only central to enhancing the quality of autonomous training for strategic national talent but also a decisive factor determining the intrinsic value and long-term success of Sino-foreign cooperative education programs.

2. Legal guidance and policy support: Top-level impetus for collaborative advancement

The formal implementation of the revised Vocational Education Law of the People’s Republic of China marks the entry of China’s vocational education reform into a new phase characterized by law-based governance and high-quality development ^[1]. Within this overarching legal framework, central and local governments have introduced a series of supporting policies and implementation rules concerning the development of “theoretical and practical dual-qualified” teaching staff. Also, these form a multi-level policy-driven system spanning “macro-level legislative safeguards,” “meso-level standard formulation,” and “micro-level mechanism innovation.” This system not only sets clear mandatory baselines but also provides broad guiding space for building “theoretical and practical dual-qualified” teaching teams in mechanical engineering Sino-foreign cooperative programs.

From the national level, a primary driving force of the policy system lies in establishing non-negotiable institutional norms and firm objectives for “theoretical and practical dual-qualified” teachers. The Standing Committee of the National People’s Congress, through the 2022 revision of the Vocational Education Law of the People’s Republic of China, affirmed the legal status of “theoretical and practical dual-qualified” teachers, explicitly stating that the state shall establish a sound training system for vocational education instructors and include practical experience as a key component of teacher evaluation ^[2]. In the same year, the Ministry of Education initiated a nationwide tiered certification process for “theoretical and practical dual-qualified” vocational education teachers by issuing the *Notice of the General Office of the Ministry of Education on*

Doing a Good Job in the Recognition of “Theoretical and Practical Dual-Qualified” Teachers in Vocational Education, providing a unified framework for provincial-level implementation rules^[3]. Building on these national guidelines, provinces have successively introduced specific measures and standards for certifying “theoretical and practical dual-qualified” teachers, transforming the previously vague concept into measurable, mandatory benchmarks. For instance, Shanxi Province has defined detailed certification criteria for junior, intermediate, and senior “theoretical and practical dual-qualified” teachers, treating both “professional practical ability” and “educational teaching ability” as core evaluation dimensions. Zhejiang Province has established a complete online application process—from individual submission to provincial filing—along with a validity period system and review mechanism. These policies require institutions to incorporate engineers from enterprises into their faculty management systems, creating an institutional pathway for two-way mobility between academia and industry.

Alongside setting policy norms, constructing a systematic incentive and support framework is crucial to guide and empower teachers in pursuing “theoretical and practical dual-qualified” status. Currently, national and local policies actively advocate for collaborative platforms such as “city-industry-education alliances,” “industry-education integration consortia,” and “productive practice-training bases” jointly developed by schools and enterprises. These platforms aim to provide authentic environments for cultivating “theoretical and practical dual-qualified” competencies, offering robust support for teachers to engage deeply in enterprise practice and participate continuously in technological research and development. As a specific paradigm for the internationalization of vocational education, the development orientation of “theoretical and practical dual-qualified” Sino-foreign cooperative education clearly reflects the nation’s pursuit of high-quality international educational substance. This strategic direction, which combines “bringing in” and “going global,” places even greater demands on “theoretical and practical dual-qualified” teachers. They must possess profound industry practice literacy, exceptional cross-cultural teaching capabilities, and a vision for global educational governance, thereby enabling a genuine transition from following and keeping pace with global standards to achieving partial leadership on the world stage.

3. Systemic contradictions and implementation challenges: Inherent obstacles in developing “theoretical and practical dual-qualified” teachers

In recent years, the transformation of manufacturing, characterized by digitalization, networking, and intelligence, has driven deep interdisciplinary integration between traditional mechanical engineering and fields such as information technology, artificial intelligence, and data science. Against this backdrop, industry expectations for mechanical engineering talent have shifted gradually from traditional skills in mechanical design and manufacturing toward the cultivation of interdisciplinary professionals capable of adapting to rapid technological iteration. This profound change in demand poses new challenges to the talent supply model of higher education, prompting a transformation in talent cultivation paradigms—from a discipline-oriented approach to one deeply integrated with industry needs, guided by industry demand^[3,4].

3.1. The core contradiction at the confluence of talent cultivation

Mechanical engineering Sino-foreign cooperative programs are currently grappling with a structural imbalance between the supply of faculty capabilities and the evolving demands of the new era, while advancing the development of “theoretical and practical dual-qualified” teaching staff. This practical dilemma is primarily reflected in the following three core contradictions: First, there is a gap between the multifaceted competency

standards required today and the existing foundation of faculty capabilities. The current educational environment demands that teachers possess not only the dual foundational abilities of “theoretical instruction” and “practical guidance” but also additional competencies in “interdisciplinary knowledge integration” and “implementation of international engineering education.” Second, there is a dual dislocation between the pace of updating faculty development systems and the speed of educational transformation. Existing professional development systems for teachers often lag behind the rapidly evolving frontiers of industrial technology. This disconnect is particularly pronounced in the context of Sino-foreign cooperative education, where insufficient localization of imported curricula in cross-cultural settings leads to misalignment between theoretical teaching and engineering practice in terms of case studies, standards, and assessments from both Chinese and foreign perspectives ^[5,6]. Third, there exists an institutional gap between the level of systematic industry-education collaboration and the need for deep, integrated development. Achieving the profound integration of industry and education advocated by the new engineering education paradigm urgently requires establishing institutionalized mechanisms for faculty exchange and collaborative curriculum development between enterprises and academic institutions ^[7]. However, current collaborative channels suffer from ambiguous roles and responsibilities among stakeholders, hindering teachers’ access to sustained, effective immersion in industrial technologies and opportunities to enhance their international teaching competencies.

3.2. The distinct implications and practical challenges in developing “theoretical and practical dual-qualified” teachers for mechanical engineering Sino-foreign cooperative programs

The practical challenges faced in the practical teaching of mechanical engineering programs stem from a systemic tension between the endogenous structure of their pedagogical framework and the rapid transformation of external industrial technology. This tension manifests specifically through three core contradictions: First, there is a contradiction between the structural lag in curriculum content and the pace of industrial technological iteration. Current teaching systems often remain confined to traditional mechanical processing frameworks, failing to adequately incorporate cutting-edge technological modules such as smart manufacturing, industrial robot integration, and digital twins. Second, there exists a contradiction between the fragmented allocation of teaching resources and the cultivation of systematic, innovative, practical capabilities. Various laboratories, platforms, and project resources lack effective integration and sharing mechanisms, making it difficult to support cross-disciplinary, comprehensive skills training. Third, there is a contradiction between the traditionally defined competencies of teachers and the interdisciplinary teaching demands of the new era. Current requirements for practical teaching have moved beyond the simple operation of equipment. Teachers are now expected to possess the ability to continuously transform “new technologies, new processes, and new standards” from industry into modular teaching resources, posing a significant challenge to both the depth of teachers’ industrial experience and their capacity for pedagogical adaptation.

4. Systematic reconstruction: A three-dimensional integrated cultivation strategy for “theoretical and practical dual-qualified” teachers in mechanical engineering

The professional development of individual teachers constitutes the logical starting point and micro-level cornerstone for cultivating a “theoretical and practical dual-qualified” teaching faculty. Its training model must fundamentally transcend the traditional paradigm of isolated and short-term approaches, transitioning instead toward constructing a systematic professional growth system grounded in practice-informed evidence ^[8,9].

4.1. Individual teacher dimension: Establishing a career development pathway centered on a “technical portfolio”

The professional growth of individual teachers forms the foundation for developing a “theoretical and practical dual-qualified” faculty, necessitating the establishment of a career-long development plan. Firstly, an “electronic professional competency development portfolio” should be created, encompassing records of engineering practice, a matrix of core technical competencies, a repository of teaching transformation outcomes, and documentation of industry certifications and social service activities. This portfolio will be developed through a tripartite collaborative mechanism involving teacher self-reporting, academic review by teaching and research units, and technical verification by partner enterprises, serving as a core basis for faculty appointment and performance evaluation to encourage continuous engagement in industrial practice. Secondly, a “modular and tiered” targeted capacity-building curriculum system should be optimized. Addressing the uneven stages of teachers’ professional development and the individualized gaps identified in their “competency development portfolios,” self-selective modules tailored to personal qualifications and professional development roadmaps should be designed. This shifts the paradigm from uniform training to needs-based empowerment, establishing a three-tier capacity-building curriculum system: for novice teachers, a foundational module focusing on basic skills such as engineering software application and routine equipment maintenance; for developing teachers, an advanced module centered on cutting-edge technologies like smart manufacturing and digital twins; and for professional leaders, a module emphasizing system integration and teaching innovation leadership, covering intelligent system planning and solutions for complex engineering problems.

4.2. Institutional dimension: Organizational transformation and institutional support driven by “structured teaching innovation teams”

Higher education institutions serve as the primary bodies responsible for developing “theoretical and practical dual-qualified” teachers. To support teachers’ cross-boundary professional growth, these institutions must undertake deep internal governance reforms. First, they should create interdisciplinary teaching innovation teams. These teams should be structured systematically. Program leaders would track industrial technological trends. Core faculty members would design curriculum content and deliver instruction. Enterprise technical experts would oversee technical standards and procedural specifications for practical projects. The core mission is to transform comprehensive, cutting-edge industrial technologies into teachable theoretical content. Teams would also develop full chain curriculum projects spanning from foundational knowledge to comprehensive application. Implementing bodies should be granted autonomy in key areas. These include budget allocation, resource integration, and performance evaluation. At the same time, an outcome-oriented holistic assessment mechanism should be established. This will help create an institutional environment that encourages deep collaboration and sustained innovation. Second, institutionalized resource support and academic development mechanisms should be constructed. Institutions need to provide substantive resource backing and systematic time protection through dedicated policies, including the establishment of a “Dual-qualified Teacher Professional Development Special Fund” focused on applied research addressing industrial needs, as well as the implementation of periodic academic sabbaticals and engineering practice programs. These initiatives allow key faculty members to undertake focused “deep learning” engagements within leading industry enterprises, dedicating time to in-depth technological exploration and strategic reflection on teaching practices.

4.3. University-enterprise collaboration: Building a “mutually embedded, shared-responsibility” community of practice

The degree of institutionalization in university-enterprise collaboration serves as a key mediating variable for the generation, iteration, and pedagogical transformation of practical knowledge among “theoretical and practical dual-qualified” teachers. It is essential to continuously advance the interaction between the two parties from sporadic engagements to a stable, institutionally embedded partnership, thereby fostering a deeply synergistic ecosystem that supports the sustained enhancement of the professional competence of “theoretical and practical dual-qualified” teachers.

First, a “dual-appointment” mechanism for position exchange and role recognition should be established. This involves systematically creating institutionalized channels for two-way personnel flow between universities and enterprises. The core of this approach lies in setting up a reciprocal system of specially designated positions that are mutually recognized. On the one hand, universities can create positions such as “Industry Professor” or “Chief Skills Specialist,” appointing experienced enterprise technicians to participate deeply in talent development and curriculum design. On the other hand, partner enterprises can establish “Technical Consultant” positions open to university faculty, allowing them to undertake research and development tasks on a full-time basis. Through this institutional design of “dual identity and dual evaluation,” a balance of rights and responsibilities, as well as a deep alignment of interests, can be achieved between both parties. Second, a project-based collaborative research and development (R&D) and pedagogical transformation process should be constructed. This entails elevating university-enterprise cooperation from the traditional model of internship-based development to an integrated “R&D-teaching” symbiotic model. Both parties collaborate to tackle real technical challenges encountered in enterprise production. Teachers, acting as core team members, are responsible for deconstructing technical solutions at each stage into teachable curriculum modules aligned with instructional design. Ultimately, this forms a complete value cycle that extends from engineering R&D to teaching practice and then feeds back into innovation ^[10].

5. Institutional innovation: Governance mechanisms for a collaborative cultivation ecosystem involving “government, industry, universities, and enterprises”

The sustainable implementation of strategies for cultivating “theoretical and practical dual-qualified” teachers relies on collaborative governance that integrates government macro-regulation, industry professional guidance, and deep execution by universities and enterprises as dual core actors. This approach systematically addresses fundamental issues such as motivational drivers, operational platforms, and quality assurance.

5.1. Motivation generation mechanism: Designing an incentive-compatible institutional framework based on “cost-sharing and benefit-sharing”

To address the asymmetric dilemma of “enthusiastic schools but reluctant enterprises” in university-industry collaboration, the key lies in constructing an incentive-compatible institutional design that delivers tangible net benefits. First, a tripartite policy package integrating “economic compensation, prioritized human resource access, and social reputation enhancement” should be established. At the government level, this includes implementing tax incentives such as the education surcharge reduction stipulated in the *Vocational Education Law*, along with providing direct financial subsidies to offset management costs and potential production disruptions for enterprises. In terms of human resources, collaborating enterprises can be granted priority selection rights in jointly trained cohorts. Regarding brand value and social capital, government authorities

or national industry associations may periodically confer honors such as “Benchmark Enterprise in Industry-Education Integration.” Second, developmental incentives for teachers should be strengthened. Practical achievements documented in the “Professional Capacity Development Portfolio” should be substantively linked to teachers’ performance-based salary distribution, professional title evaluation, and appointment. A “Dual-Qualified Teacher Award for Outstanding Teaching Contribution” can be established to legitimize “practical scholarship” within the academic evaluation system, thereby rewarding teachers who excel in translating technological outcomes into teaching practices or solving significant technical challenges for enterprises.

5.2. Process operation mechanism: Building a dual-driven implementation framework of “physical platforms and collaborative governance organizations”

A well-defined collaborative process, supported by solid physical and organizational structures, is essential to institutionalize and sustain the partnership. First, jointly built, jointly managed, and shared physical collaboration platforms should be established^[11,12]. Drawing inspiration from Germany’s “InterCompany Training Center” model, it is advisable to promote the construction of “Regional Smart Manufacturing IndustryEducation Integration Innovation Platforms.” These platforms would be led and coordinated by local governments, organized by industry associations, and jointly funded by leading enterprises and higher education institutions. Through intensive resource development and shared utilization, such platforms maximize investment efficiency and provide a stable, advanced public practice environment for the development of “theoretical and practical dual-qualified” teachers. Second, governance bodies and standardized decision-making mechanisms for universityenterprise collaboration should be established. A legally constituted “IndustryEducation Integration Collaborative Development Committee” with clearly defined rights and responsibilities should be formed. This committee would be primarily responsible for jointly reviewing and approving “theoretical and practical dual-qualified” teacher training plans, authoritatively coordinating and implementing engineering practice positions for teachers, managing the hardware and software resources of jointly built platforms, and evaluating and adjusting the annual outcomes of collaboration projects. Committee members should include senior management representatives from both universities and enterprises, key technical and teaching department heads, as well as independent industry experts. Through regular meetings, formal resolutions, and transparent information disclosure, the institutionalized operation of the committee will ensure strategic stability throughout the collaborative process.

5.3. Evaluation and safeguard mechanisms: Introducing a system of “industry standard certification and multi-stakeholder quality monitoring”

An objective third-party evaluation standard should be introduced to ensure the cultivation quality and social recognition of “theoretical and practical dual-qualified” teachers. First, a professional certification system based on industry competency standards should be established. This involves aligning teacher training, professional development, and qualification recognition with industry benchmarks. Teachers should be encouraged to obtain additional certifications issued by industry organizations, such as “Enterprise Trainer” or “Engineering Technical Education Teacher.” Concurrently, student skill assessments and graduation requirements should be linked to authoritative industry certifications, ensuring that teachers’ own competency structures consistently align with the latest industry demands. Second, a closed-loop quality monitoring and feedback mechanism that “integrates internal and external oversight with multi-stakeholder participation” should be established. Internal quality assurance relies on institutional teaching supervision, student evaluations, and teacher self-assessment.

External quality monitoring incorporates evaluations from core partner enterprises, third-party industry assessments, and broader societal feedback. Evaluation results are regularly reported to the “Industry Education Integration Collaborative Development Committee” and serve as key evidence for optimizing training programs and improving collaborative mechanisms. This process fosters a dynamic, self-diagnosing, self-correcting, and self-improving capacity for continuous enhancement.

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