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Integration of Industry and Education Training Model and Evaluation System for Postgraduates Majoring in Mechanical Engineering in the Context of New Engineering

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Abstract: The concept of "New Engineering" represents both a cutting-edge exploration in the global transformation of engineering education paradigms and a strategic initiative by China's higher education sector to proactively adapt to the new economic landscape. Against this backdrop, postgraduate education is actively promoting interdisciplinary integration and the innovation of engineering education paradigms, making the systematic reconstruction of the quality evaluation system for professional degree postgraduates an urgent necessity. This paper explores three key aspects: how to construct a curriculum system that integrates engineering practice and disciplinary frontiers for mechanical majors, how to build an industry-education integration-driven practical platform for mechanical majors, and how to establish a diversified evaluation and feedback system for postgraduate training. It aims to provide new ideas and solutions for postgraduate education, enabling it to meet the demands of the new technological revolution and industrial transformation, drive the strategic transformation of postgraduate training, and provide high-quality talent support for the development of New Engineering.

1. Introduction

The development of New Engineering is a core strategic measure taken by the country to respond to the new round of technological revolution and industrial transformation. It aims to serve the national strategic needs and support the development of future industries by reconstructing the engineering education paradigm to facilitate innovation-driven development, representing an educational reform direction focused on the systematic restructuring of traditional engineering discipline systems [1]. As a key driver for promoting the coordinated development of higher education and modern industries, the integration of industry and education has achieved remarkable results in the past and holds immense potential and broad prospects for future development. In the days ahead, this integration will continue to deepen, moving toward all-round, multi-level, and in-depth integration [2]. With the widespread application of digital and intelligent technologies in the industrial sector, the integration of industry and education will also accelerate its digital transformation. By advancing in-depth interdisciplinary integration and industry-education collaborative innovation, efforts will be made to cultivate compound engineering talents with disruptive technological innovation capabilities, systematic solution design capabilities, and international competitiveness. This will provide high-level talent support and a strategic engine for the country to seize the commanding heights of future technology and build a modern industrial system [3].

In the context of New Engineering development, postgraduate education is actively promoting interdisciplinary integration and the innovation of engineering education paradigms. Its core lies in breaking down the deep-seated barriers in the integration of industry and education, cultivating high-end application-oriented talents with both engineering implementation capabilities and industrial innovation capabilities, and shaping outstanding engineers who can quickly respond to industrial transformations [4]. The training model for professional degree postgraduates is undergoing a systematic reform and is confronted with multiple challenges. Firstly, there exists a contradiction between the interdisciplinary curriculum system and the traditional single-discipline knowledge structure of supervisors, which makes it difficult to effectively provide academic guidance in cutting-edge interdisciplinary fields [5]. Secondly, the integration of engineering practice and theoretical innovation is insufficient, and the industry-education collaboration mechanism is not yet mature, which restricts the cultivation of postgraduates' ability to solve complex real-world problems [6]. Thirdly, the rapid iteration of technological trends and the relative lag of training programs create tensions, placing higher demands on the dynamic adaptability of teaching content [7]. Fourthly, the cultivation of soft skills such as ethical literacy and systematic thinking has not yet formed a standardized evaluation system, making them prone to being marginalized in the pursuit of technological breakthroughs [8]. These challenges urgently require systematic solutions through the reconstruction of supervisor teams, the deepening of industry integration, and the establishment of a flexible curriculum mechanism.

Against the backdrop of New Engineering, the quality evaluation system for professional degree postgraduates is in urgent need of systematic reconstruction. It is essential to break away from the traditional single-dimensional focus on academic theses, introduce diversified evaluation subjects including industry experts, and incorporate core indicators such as the efficiency of enterprise technology transformation and the value of patents in solving practical industrial problems [9]. Emphasis should be placed on the evolution of postgraduates' systematic thinking and the development of cross-field collaboration capabilities in complex engineering scenarios [10], as well as the assessment of their ability to anticipate social risks of technical solutions and the contribution of these solutions to sustainable development [11]. Ultimately, an intelligent evaluation system that covers the entire training cycle and dynamically reflects industrial technology iterations will be formed, driving the integration of industry and education toward in-depth strategic development [12].

2. Construction of a Curriculum System Integrating Engineering Practice and Disciplinary Frontiers for Mechanical Majors - Modular Curriculum Group Design and Dynamic Adjustment Mechanism

2.1 Dynamic Response Mechanism of the Curriculum System

The dynamic response mechanism of the curriculum system serves as the core support for mechanical majors to adapt to the development of New Engineering and achieve in-depth collaboration between education and industry. With the law of industrial technology evolution at its core, this mechanism does not rely on subjective judgments. Instead, it establishes an annual curriculum iteration system based on Industry Technology White Papers, Industrial Development Roadmaps, and Annual Reports on the Demand for Scarce Talents, ensuring that adjustments are conducted in a rule-based manner. These documents compile cutting-edge industrial trends, long-term development directions, and the actual situation of talent gaps. The annual iteration based on such information not only ensures that teaching content remains aligned with the forefront of science and technology, avoiding knowledge obsolescence, but also enables the curriculum system to break free from the traditional static framework and become an active driver of industrial innovation and technological breakthroughs. Ultimately, it achieves a high degree of dynamic alignment between educational supply and industrial demand, ensuring that talent cultivation accurately meets the needs of industrial development.

Data collection serves as a crucial foundation for the effective operation of this mechanism. Relying on the industry technology monitoring centers co-established by universities and enterprises, real-time collection of multi-dimensional data related to strategic emerging industries can be realized, including technical parameters, production capacity conversion needs, and changes in skill structures. This real-time data provides an accurate practical basis for curriculum adjustments, avoiding blind reforms. Meanwhile, the university-enterprise joint model allows enterprises to deeply participate in data interpretation, ensuring that the collected information truly meets the needs of front-line production rather than remaining confined to theoretical technical analysis.

The technical assessment link is equally indispensable. By constructing a curriculum adaptability evaluation model using machine learning algorithms, in-depth analysis of the collected data can be conducted to identify the degree of deviation between existing courses and cutting-edge technologies, and quantify this deviation. This provides clear directions for subsequent adjustments. Compared with traditional manual judgments, this quantitative assessment method is more objective, effectively reducing adjustment deviations caused by differences in personal experience and making curriculum optimization more scientific and efficient.

Finally, the Curriculum Dynamic Adjustment Committee, composed of members from the academic committee and industrial experts, will conduct annual reorganization and optimization of curriculum modules based on data feedback and model assessment results. For enterprises, this helps fill the gaps in teaching in cutting-edge fields; meanwhile, flexible curriculum modules, such as short-term specialized courses tailored to the specific technical needs of certain enterprises, are added to further enhance the flexibility and pertinence of the curriculum system. For students, the dynamically adjusted curriculum enables them to access the latest industrial technologies and concepts during their studies. Upon graduation, they can quickly adapt to job requirements without additional training, which not only enhances their personal employability but also saves enterprises the cost of talent cultivation, creating a win-win situation for students, universities, and industries.

2.2 Modular Construction of the Curriculum System

The modular construction of the curriculum system is a key approach for mechanical majors to align with the development of New Engineering and achieve a hierarchical talent cultivation model encompassing "foundation - major - practice".

At the basic curriculum level, the knowledge boundaries of traditional mechanical disciplines are broken through, and interdisciplinary basic modules such as Industrial Big Data Analysis and Intelligent Sensing and Edge Computing are added. These modules not only cover the core knowledge of data collection, processing, and edge device application but also integrate industry scenarios such as mechanical equipment condition monitoring and production data visualization through case-based teaching. This enables students to establish a connection between "technical tools and mechanical applications" while mastering digital technology theories, laying a solid foundation for digital literacy and interdisciplinary learning, and building a professional knowledge framework for subsequent major studies.

At the core professional curriculum level, closely adhering to the national layout of strategic emerging industries, key efforts are made to develop cutting-edge courses such as Digital Twin and Equipment Operation and Maintenance, Additive Manufacturing of Composite Materials, and AI-Driven Design and Simulation. All these courses are oriented toward actual industrial needs. For instance, Digital Twin and Equipment Operation and Maintenance focuses on the full-life cycle management needs in fields such as high-end machine tools and engineering machinery, integrating real enterprise processes of digital twin model construction and cases of operation and maintenance algorithm optimization. Additive Manufacturing of Composite Materials addresses the demand for lightweight components in the aerospace and new energy vehicle industries, covering core skills such as material selection, process parameter optimization, and quality inspection. This ensures that the professional knowledge mastered by students directly aligns with the cutting edge of industrial technology, enhancing their job adaptability.

At the practical innovation level, to overcome the traditional dilemma of "disconnection between theoretical teaching and practice", immersive courses such as Case Studies on Intelligent Equipment Upgrading and Project Practice on Digital Transformation of Production Lines are jointly developed through the establishment of industry case libraries and dual-tutor workshops by universities and enterprises. Universities and enterprises work together to select representative technology research projects, decomposing these real projects into teaching links including "demand analysis - scheme design - technical implementation - result acceptance". University teachers are assigned to provide theoretical guidance, while enterprise tutors are responsible for practical teaching, allowing students to participate in the entire process as "project team members". Meanwhile, the courses also introduce tools commonly used in enterprises, such as simulation software and operation and maintenance platforms, and require students to complete the entire process from scheme reporting to prototype verification. This "project-as-teaching" model not only transforms industrial innovation resources into high-quality teaching resources but also enables students to enhance their problem-solving and team collaboration capabilities through practical experience. Ultimately, it achieves dynamic alignment between educational supply and industrial innovation, providing industries with compound talents who are "capable of practical work and innovative thinking".

3. Construction of an Industry-Education Integration-Driven Practical Platform for Mechanical Majors - Industry Demand-Driven Teaching Transformation Mechanism and Virtual-Physical Collaborative Platform Architecture

3.1 Industry Demand-Driven Teaching Transformation Mechanism: Establishing an Accurate Link between "Technology and Teaching"

The establishment of a real-time synchronization mechanism between enterprise technology roadmaps and university syllabi serves as the core link for achieving in-depth industry-education integration. By building a university-enterprise data sharing platform, the previous "information island" dilemma between universities and enterprises is broken, enabling access to core data such as enterprise technology R&D progress, product iteration cycles, and production capacity upgrading plans. On this basis, the industrial technology evolution path, product iteration logic, and production capacity upgrading needs are dynamically mapped to the curriculum system, and a dynamic adjustment algorithm model is constructed. When enterprises introduce new technologies, the model can automatically suggest the optimization of corresponding curriculum modules, ensuring that the competency profile of professional degree postgraduates remains dynamically aligned with industrial innovation needs, and achieving in-depth integration between the education chain and the innovation chain.

3.2 Virtual-Physical Collaborative Platform Architecture: Building a Closed-Loop Ecosystem of "Simulation - Trial Production - Implementation"

The integration of a closed-loop iterative system consisting of "virtual verification - physical optimization - industrial implementation" into teaching is crucial for enhancing the effectiveness of practical teaching. Firstly, digital twin technology is used to construct a virtual production line that replicates the real production scenarios of enterprises. Students can test technical schemes in the simulated environment, avoiding risks associated with physical operations. Subsequently, physical trial production is carried out in the pilot-scale test bases co-established by universities and enterprises. Enterprise tutors provide guidance on process details and collect production data (such as product qualification rates), which is then fed back to the teaching process to optimize the schemes. Finally, the mature schemes are applied in the industrial sector, and new problems arising during large-scale production are fed back to teaching and research. This closed-loop system not only aligns talent cultivation with the pace of industrial development but also serves as a core hub for university-enterprise collaborative innovation.

4. Construction of a Diversified Evaluation and Feedback System for Postgraduate Training - The "Academic-Engineering" Dual-Track Evaluation Mechanism for Industry-Education Collaboration

4.1 Diversification of Evaluation Subjects: Building an Evaluation Community with In-Depth University-Enterprise Integration

Breaking away from the traditional single evaluation model dominated by universities, a diversified evaluation subject system featuring university-enterprise collaboration is established, forming a comprehensive evaluation closed loop covering "academic capabilities - engineering practice". University supervisor teams take the lead in academic evaluation, focusing on the integrity of the disciplinary system and the standardization of academic research. They comprehensively assess postgraduates' theoretical innovation capabilities, the depth of disciplinary knowledge reserves, and academic standard literacy. The evaluation is based on indicators such as the logical rigor of academic course reports, the innovation of theoretical modeling, and the academic value of academic papers, ensuring that the evaluation meets the rigorous requirements of academic research.

Simultaneously, an engineering evaluation team is established, composed of enterprise chief engineers, industrial tutors, and industry experts. Leveraging their industrial practical experience and professional technical perspective, the team focuses on assessing postgraduates' core practical capabilities in real engineering scenarios, including technical application capabilities, systematic solution design capabilities, as well as engineering ethics awareness and team collaboration capabilities. The evaluation is conducted based on specific indicators, such as the technical value and application potential of patents, the industrial feasibility of technical schemes, and the actual effects of project implementation. Additionally, the scope of achievement evaluation is expanded to include industry technical standard proposals, R&D patents, software copyrights, engineering acceptance reports, and innovative product prototypes.

On this basis, a university-enterprise joint evaluation committee is established to coordinate academic and engineering evaluation work. The two parties jointly formulate evaluation standards, review the results of interdisciplinary projects, and assign equal weight to the evaluation results from industrial tutors and academic evaluations. This truly achieves in-depth integration of academic rigor and engineering feasibility, avoiding the one-sidedness of "overemphasizing theory while neglecting practice" or "overemphasizing application while neglecting innovation".

4.2 Diversification of Evaluation Content: Establishing Three-Dimensional Evaluation Indicators Covering Technology, Management, and Ethics

Breaking through the single technical capability evaluation framework, a multi-dimensional evaluation content system featuring the "technology - management - ethics" trinity is constructed, fully meeting the industrial demand for compound engineering talents. The technical dimension focuses on core practical value, evaluating postgraduates' efficiency in solving technical pain points, the actual value of achievement transformation, and their role in promoting production line upgrading in the context of real industrial technical needs. This ensures that the evaluation directly targets industrial application scenarios, avoiding "empty talk".

The management dimension emphasizes the assessment of comprehensive capabilities. From the perspective of the entire engineering project cycle, it evaluates postgraduates' collaboration efficiency in interdisciplinary teams, project overall management capabilities, and cost control awareness. It highlights the systematic thinking and resource integration capabilities in engineering practice, fostering their engineering management literacy that meets industrial requirements.

The ethics dimension strengthens the guidance of social responsibility. Indicators such as the assessment of the social impact of technical schemes and engineering ethics decision-making capabilities are added to guide postgraduates to balance social value and ethical standards in the process of technological innovation, and establish a sense of responsible innovation.

5. Conclusion

The curriculum system, practical platform, and diversified evaluation and feedback system constructed in this paper not only effectively address the prominent issues of "disconnection between theory and practice" and "misalignment between educational supply and industrial demand" in the training of professional degree postgraduates in the mechanical field but also provide a systematic solution from the institutional design perspective for postgraduate education to adapt to the needs of the new technological revolution and industrial transformation. Through the coordinated linkage of "curriculum - platform - evaluation", this system not only ensures the coordinated improvement of postgraduates' academic literacy and engineering capabilities but also achieves the synchronous development of university talent cultivation and industrial innovation. Ultimately, it provides a promotable practical paradigm for the development of New Engineering, offers strong support for the cultivation of high-quality talents adapting to industrial transformation in the mechanical field and even other engineering disciplines, and holds significant practical significance for promoting the connotative development of higher engineering education and serving the upgrading of national strategic emerging industries.

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