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Research on the Optimization and Innovation of Practical Teaching Systems for Mechanical Engineering Majors in the Context of New Engineering Education

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Abstract: The New Engineering Education model is guided by the core principles of interdisciplinary integration and industry-education collaboration, with a focus on cultivating high-caliber, outstanding engineering professionals. Current practical teaching in mechanical engineering programs faces challenges such as misaligned objectives, monotonous methodologies, inadequate evaluation systems, and underdeveloped industry-education partnerships. To address these issues, strategies-including refining practical learning objectives, innovating teaching approaches, enhancing evaluation frameworks, and strengthening university-industry collaboration-should be implemented to ensure precise alignment between practical instruction and the requirements of New Engineering Education as well as industry needs, thereby elevating the quality of talent development.

Keywords: New Engineering; Mechanical Engineering; Teaching System; Practical Strategies

1. Introduction

The latest wave of technological revolution and industrial transformation is driving the mechanical industry toward intelligent, digital, and green development, with the new engineering education philosophy providing clear direction for reforming engineering education. As a core domain of engineering education, practical teaching in mechanical disciplines is crucial for cultivating students' engineering literacy and practical skills. However, the current practical teaching system struggles to meet the demands of industrial transformation and the needs of cultivating new engineering talents, necessitating urgent optimization and innovation to overcome developmental bottlenecks.

2. The Core Connotation and Characteristics of New Engineering Disciplines

The New Engineering Education represents a paradigm for engineering education reform that aligns with the new round of technological revolution and industrial transformation, serving the national innovation development strategy. Guided by the principle of fostering virtue and nurturing talents, it upholds the concepts of inheriting and innovating, interdisciplinary integration, and industry-education collaboration. Its core characteristics include cross-disciplinary integration, dynamic professional upgrading, and diversified talent cultivation, emphasizing the deep integration of theory and practice. Focusing on emerging fields such as intelligent manufacturing and digital technologies, it aims to cultivate high-quality, outstanding engineering professionals equipped with strong engineering literacy, innovative capabilities, and practical application skills.

3. Current Status of the Practical Teaching System for Mechanical Engineering Majors in the Context of New Engineering Education

3.1 The Disconnect between Practical Teaching Objectives and the Demands of New Engineering Talent

In the context of New Engineering Education, the machinery industry is undergoing a transformation toward intelligence, digitalization, and sustainability, imposing higher demands on professionals 'innovative capabilities, cross-disciplinary integration skills, and ability to solve complex engineering problems. Currently, practical teaching objectives in mechanical disciplines remain outdated, primarily focusing on mastering fundamental skills such as traditional manufacturing processes and equipment operation, with an emphasis on verifying theoretical knowledge and training basic operational skills, while lacking systematic cultivation of students' innovative thinking, digital literacy, and comprehensive engineering practice abilities [1]. Some practical teaching objectives fail to adequately align with job requirements in emerging fields like smart manufacturing, industrial robotics, and intelligent equipment, and do not integrate cutting-edge industrial technologies and real-world engineering challenges into the teaching framework. This results in graduates struggling to quickly adapt to corporate job requirements, creating a significant gap between current practices and the goal of cultivating high-caliber, outstanding engineering professionals advocated by New Engineering Education.

3.2 The Practical Teaching Methods and Approaches Are Too Limited and Rigid.

Current practical teaching in mechanical engineering programs remains predominantly reliant on traditional methods, exhibiting a monolithic and rigid approach that fails to meet the diversified demands of cultivating talents for new engineering disciplines. The conventional "teacher demonstration, student imitation" model forces students into passive participation, leaving little room for active critical thinking or independent exploration-thereby hindering the cultivation of innovative awareness and practical enthusiasm. Teaching methodologies still depend heavily on conventional laboratory equipment and training facilities, with insufficient adoption of digital and intelligent teaching tools. Emerging approaches such as virtual simulation, online training, and project-based learning remain underutilized [2]. Many practical components remain confined to isolated, single-course exercises, lacking interdisciplinary or cross-disciplinary comprehensive projects. This limitation prevents students from developing the ability to integrate multidisciplinary knowledge to solve complex engineering problems, contradicting the core principles of new engineering education that emphasize interdisciplinary integration and practical innovation.

4. Optimization and Innovation Strategies for the Practical Teaching System of Mechanical Engineering Majors in the Context of New Engineering Education

4.1 Optimize the Practical Teaching Objective System to Align with the Talent Cultivation Requirements of New Engineering Disciplines

Optimizing the practical teaching objective system serves as the core prerequisite for reforming practical education in mechanical engineering disciplines under the New Engineering Education framework. This requires close alignment with the talent cultivation objectives of New Engineering Education and the transformation needs of the mechanical industry, establishing a hierarchical, categorized, and dynamically adjustable practical teaching objective system. Guided by the principle of fostering moral integrity and talent development, the system should focus on core competencies in mechanical engineering-innovation capability, digital literacy, engineering practice skills, and cross-disciplinary integration abilities-overcoming the traditional emphasis on basic operational skills. By incorporating job requirements from emerging fields such as smart manufacturing, industrial robotics, and intelligent equipment, practical teaching objectives are refined into three levels: foundational, comprehensive, and innovative practice objectives. Foundational objectives emphasize consolidating traditional mechanical skills; comprehensive objectives prioritize solving complex engineering problems; while innovative objectives highlight cultivating students 'creative thinking and technology commercialization capabilities. A dynamic adjustment mechanism for practical teaching objectives should be implemented, involving regular industry surveys, technical trend analyses, and collaborative revisions with corporate experts and industry associations. This ensures integration of cutting-edge industrial technologies and real-world engineering demands into the objective system, aligning practical education with New Engineering Education's talent cultivation requirements and achieving precise alignment between academic training and corporate needs [5].

4.2 Reform Practical Teaching Methods and Approaches to Enhance the Effectiveness of Practical Instruction

4.2.1 Promote Project-based, Case-based, and Flipped-classroom Teaching Methods

Promoting project-based, case-based, and flipped classroom teaching methods serves as a pivotal strategy to transform traditional practical education models and enhance their effectiveness, aligning with the interdisciplinary and innovation-driven talent cultivation philosophy of modern engineering education. Project-based teaching utilizes real-world engineering projects as its foundation, tailored to mechanical engineering disciplines, to design comprehensive practical projects covering mechanical design, manufacturing, and intelligent upgrades. Students work in project teams, participating throughout the entire process-from project research and design planning to hands-on implementation and outcome evaluation-integrating multidisciplinary knowledge to strengthen practical skills and innovative thinking while solving real-world engineering challenges. Case-based teaching selects representative engineering examples from the mechanical industry, particularly cutting-edge applications like smart manufacturing and intelligent equipment, guiding students through in-depth analysis, discussions, and simulated practices that closely link theoretical knowledge with engineering realities, thereby cultivating problem-solving capabilities. Flipped classroom teaching restructures the instructional workflow: pre-class materials-including practical videos, concept explanations, and preview tasks-are delivered via online platforms to facilitate self-directed learning. In class, focus shifts to addressing key practical challenges through group discussions, hands-on guidance, and project presentations, transforming students from passive knowledge recipients to active practitioners. This approach fully stimulates students' enthusiasm for hands-on learning and autonomous acquisition, achieving a shift from "teaching how to do" to "learning how to learn" and "applying knowledge effectively."

4.2.2. Building a virtual simulation practice platform based on information technology

By leveraging information technology to establish a virtual simulation practice platform, we can address the limitations of traditional practical teaching resources and expand practical learning scenarios, aligning with the digital and intelligent development trends in modern engineering education. Integrating the characteristics of mechanical engineering practice with virtual simulation technology, big data analytics, and artificial intelligence enables the creation of a comprehensive virtual simulation platform encompassing modules such as mechanical design, manufacturing, smart production, and equipment maintenance. This platform simulates authentic engineering scenarios and operational workflows while overcoming temporal and spatial constraints. Traditional practices face challenges including expensive equipment, high operational risks, and limited training environments. The virtual simulation platform facilitates high-risk, high-cost, and complex hands-on training-including large-scale equipment debugging, intricate component manufacturing, and intelligent production line operations. Through repeated practice and exploration in a virtual environment, students reduce practical costs and safety risks while enhancing operational proficiency and standardization. Combining virtual simulation with offline practical training establishes a closed-loop teaching model featuring virtual simulation preparation, hands-on practice, and virtual post-training optimization. This approach enriches both the content and format of practical instruction, improves learning engagement and effectiveness, and equips students with digital operational skills essential for adapting to the intelligent transformation of the mechanical industry.

4.3 Improve the Practical Teaching Evaluation System to Achieve Diversified, Whole-process Assessment

4.3.1. Establish an evaluation model that combines process evaluation with outcome evaluation

The evaluation model that integrates formative and summative assessments serves as a pivotal measure to overcome traditional single-outcomes-oriented evaluations and comprehensively reflect students 'practical competencies, aligning with the assessment requirements for new engineering education. Moving away from the previous static evaluation approach focused on practical reports and training outcomes, this model incorporates formative assessment throughout practical instruction, emphasizing students' participation, hands-on skills, innovative thinking, collaborative abilities, and problem-solving capabilities. This is achieved through quantitative and qualitative evaluations via classroom performance, hands-on records, group presentations, and interim deliverables. Summative assessment focuses on evaluating final practical outcomes-including practical reports, training projects, and innovative achievements-emphasizing their practical applicability, innovation, and standardization, while avoiding simplistic judgments based solely on correctness. By clearly defining the weight distribution between formative and summative assessments (with formative assessment accounting for no less than 50%), refining evaluation indicators tailored to mechanical engineering practices, and establishing scientific standards, the model ensures comprehensive and objective assessment content, enabling accurate evaluation of students' practical abilities and overall competencies while maximizing the guiding and motivational role of evaluation in practical teaching.

4.3.2. Introduce mechanisms for industry and enterprise evaluation, student self-assessment, and peer assessment

The implementation of industry enterprise evaluations, student self-assessments, and peer review mechanisms constitutes a vital component in refining the practical teaching evaluation system and achieving diversified assessment approaches. This enhances the relevance and objectivity of evaluations, aligning with the talent development philosophy of industry-education integration in new engineering disciplines. By collaborating with enterprises, corporate mentors and industry experts are invited to participate in practical teaching evaluations. These assessments integrate real-world job requirements, evaluating students 'performance based on operational standardization, engineering literacy, and job relevance to ensure alignment with corporate needs. A student self-assessment mechanism encourages comprehensive reflection on practical processes, learning attitudes, achievements, and shortcomings, fostering self-reflection and autonomous learning capabilities. Peer review mechanisms enable practice groups to evaluate each other's performance, collaboration skills, innovative ideas, and project quality, promoting mutual learning, supervision, and collective improvement. Additionally, a feedback mechanism promptly communicates evaluation results to both students and instructors, providing targeted recommendations for enhancing the practical teaching process and elevating instructional quality.

4.4 Deepen Industry-education Integration and School-enterprise Collaboration to Establish High-quality Practical Platforms

4.4.1. Jointly establish a school-enterprise collaborative practice base

The industry-academia collaborative practice base serves as a vital platform for advancing industry-education integration and establishing high-quality practical training facilities. By leveraging complementary resources from both parties, this initiative enhances the relevance and effectiveness of practical education. Aligned with the practical teaching requirements for mechanical engineering disciplines, the base was established in partnership with leading industry enterprises under the principles of complementary strengths, resource sharing, and collaborative talent development. It encompasses comprehensive functions including instruction, hands-on training, research, and career placement. Embracing the trend of intelligent transformation in the machinery sector, the base is equipped with advanced training facilities, testing instruments, and smart production lines that simulate real-world manufacturing scenarios, providing students with immersive practical experiences. Both institutions jointly develop management protocols and training programs, with enterprises providing physical facilities, technical support, and mentorship while participating in instructional guidance.

4.4.2. Promote collaborative development of practical projects and joint curriculum development between schools and enterprises

The collaborative development of practical projects and curriculum design by schools and enterprises serves as the primary approach to deepen industry-education integration and ensure precise alignment between practical teaching content and industry demands, aligning with the core requirements of the New Engineering Education reform. Joint teaching teams formed by both parties develop practical teaching projects based on actual corporate production scenarios and industry technological trends. These projects feature practicality, innovation, and comprehensiveness, covering areas such as mechanical design, manufacturing, intelligent transformation, and equipment operation and maintenance. By integrating real-world engineering challenges with cutting-edge technologies, students enhance their engineering literacy and innovation capabilities through problem-solving. Schools and relevant institutions jointly establish practical curriculum frameworks, eliminating barriers between traditional courses by incorporating corporate job competency requirements into curriculum content, adjusting course structures, and adding practical modules in emerging fields like smart manufacturing, industrial robotics applications, and digital twins. Enterprises and schools collaboratively produce practical textbooks and teaching materials, with companies providing up-to-date engineering case studies, technical standards, and job specifications. Schools refine the theoretical frameworks and adapt them for teaching, ensuring curriculum content remains synchronized with industry demands and technological advancements.

5. Epilogue

In the context of new engineering education, optimizing the practical teaching system for mechanical engineering disciplines is an essential requirement for adapting to industry transformation and achieving talent development objectives. By addressing key challenges in practical teaching-including objectives, methodologies, evaluation, and collaboration-while advancing reforms and innovations, we can enhance the quality and efficiency of practical instruction. This approach enables the cultivation of high-caliber engineering professionals with both innovative capabilities and practical competencies for the mechanical industry, thereby supporting the implementation of the national innovation development strategy.

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