Teaching Reform and Practice of Mechanical Manufacturing and Automation Courses in the Context of Intelligent Manufacturing

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Abstract. Amidst the rise of intelligent manufacturing, China's mechanical manufacturing and automation majors are undergoing significant industry-education integration. This article proposes a talent training model reform rooted in competency-based education, aimed at addressing industrial transformation effectively. The core of this reform involves creating a new training system that integrates knowledge, skills, and qualities. Curriculum adjustments include the addition of applied modules like engineering training and project practice to enhance students' problem-solving abilities. Teaching methods prioritize hands-on practice through case studies and project-driven learning to bridge theory and practice. Practical experience is gained through close collaboration with enterprises, providing students with real-world engineering exposure. A dynamic monitoring system for knowledge, competencies, and employment quality has been established, yielding substantial results. This reform has produced highly skilled, adaptable talents recognized by businesses, supporting China's shift towards intelligent manufacturing in the mechanical manufacturing sector.

Keywords: Intelligent Manufacturing; Mechanical Manufacturing and Automation; Professional Education; Reform Path; Effectiveness Assessment

1 Introduction

The need for reform in the education of mechanical manufacturing and automation majors has grown significantly due to the rise of intelligent manufacturing [1]. This integration of new-generation IT and traditional manufacturing has created fresh demands for core technologies and industry-specific skills. However, current education content and methods fall short of addressing these needs, calling for reform and innovation. To align education with economic and social development, this paper analyzes the challenges in professional education and explores how intelligent manufacturing necessitates changes. It suggests a competency-based, industry-education integrated training model and targeted reforms in curriculum design, teaching methods, and practical experiences. Through a dynamic monitoring system and reform evaluation, the paper aims to offer insights for educational reform [2].

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2 Challenges faced by mechanical manufacturing and automation major courses

China's rapidly evolving industries have transformed talent demands in mechanical manufacturing and automation [3]. Previously, the focus was on traditional manufacturing, but the surge in intelligent manufacturing and digital workshop construction now requires versatile skills in mechanical design, sensors, actuators, and control algorithms. This necessitates timely curriculum adjustments, emphasizing data analysis, system integration, and hands-on training. Current courses often lean heavily on theory and neglect technological advancements [4]. To bridge this gap, reforms should incorporate cutting-edge knowledge like digital design, sustainable manufacturing, and project-driven learning. Assessment methods should shift from closed-book exams to design-based projects, fostering practical problem-solving abilities. Strengthening university-industry cooperation and hands-on experiences are essential for preparing students for multifaceted industry demands. Ongoing teaching innovations are vital to support industrial transformation effectively.

3 New requirements of intelligent manufacturing for the teaching of mechanical manufacturing and automation

3.1 Impact of core technologies of intelligent manufacturing on the curriculum system

Intelligent manufacturing, born from the fusion of new-generation IT and traditional manufacturing, involves key technologies like perception, big data analysis, system control, and collaborative optimization[5]. Research predicts the industry's scale to reach 15 trillion yuan by 2025, demanding curriculum adjustments for mechanical manufacturing and automation majors. Curriculum updates should include intelligent equipment, sensor tech, industrial big data analysis, digital design, and simulation. Teaching methods should emphasize task-driven and project-based learning, fostering practical problem-solving skills. Assessments should incorporate design and research evaluations to gauge innovation and hands-on capabilities[6]. Aligning professional education with industrial tech advances is vital for nurturing skilled talent for intelligent manufacturing.

3.2 Enhancement of core competencies in the profession

In the realm of intelligent manufacturing, mechanical manufacturing and automation programs must expand beyond traditional mechanical skills. Key competencies now encompass automatic control, sensor technology, optimization algorithms, system integration, data-driven analysis, and decision-making. This necessitates program adjustments with competency-based modules and heightened practical teaching[7]. Courses with a practical orientation, like intelligent equipment and system design, testing, and control, should be integrated. Project-based training models are vital for nurturing students' problem-solving skills and comprehensive abilities across disciplines. Strengthening university-industry collaborations is essential to provide students with real-world production settings, fostering engineering awareness and expertise in operating and maintaining advanced equipment and complex systems. This approach ensures the competitiveness of graduates in today's job market.

4 Teaching reform strategies and measures for mechanical manufacturing and automation majors

4.1 Overall reform strategy

In response to evolving talent needs in intelligent manufacturing, the teaching reform strategy for mechanical manufacturing and automation majors, as depicted in Figure 1, centers on close alignment with industry trends and cutting-edge technology. It entails optimizing program structures, integrating course resources, and establishing a "three-in-one" talent training model encompassing knowledge, skills, and qualities[8]. This model seeks to seamlessly bridge professional education and industry requirements, prioritizing core intelligent manufacturing technologies. It involves adjusting the existing curriculum and introducing new modules in emerging interdisciplinary fields like data-driven decision-making, intelligent control, and optimization. Teaching methods should shift towards project-based and case-driven approaches, emphasizing practical components and fostering students' engineering awareness, innovation mindset, and comprehensive problem-solving skills.

Figure 1. Overall Reform Strategy

4.2 Decomposition of reform principles and implementation mapping

The reform in professional education follows three fundamental principles: industry-education integration, competency-based education, and modular construction[9]. Industry-education integration involves enhancing collaboration between universities and industries, inviting industry experts to teach, and ensuring alignment between industry needs and education. Competency-based education focuses on developing students' problem-solving abilities, aligning courses with industry requirements, using project-based teaching, and assessing engineering skills[10]. Modular construction enables flexible allocation of resources, allowing timely adjustments to the curriculum to match industrial advancements. These principles guide the reform, optimizing training programs, updating course content, improving teaching methods, and ensuring practical conditions.

4.3 Main measures of reform implementation

The main measures for implementing the reform in the field of intelligent manufacturing include the establishment of a unique talent cultivation system, the development of specialized training specifications tailored to job demands, the optimization of curriculum structures, and the incorporation of practical engineering components, as shown in Figure 2. Additionally, a core curriculum group is being created to cover topics such as intelligent devices, automation system integration, and digital production management. To enhance teaching methods, project-based and scenario-based approaches are being promoted to foster problem-solving skills and systemic thinking among students. Furthermore, collaborative training bases are being established in partnership with enterprises, where students can gain practical experience in real production line environments. These measures collectively aim to shift the educational focus from theory-centric instruction to the development of comprehensive abilities.

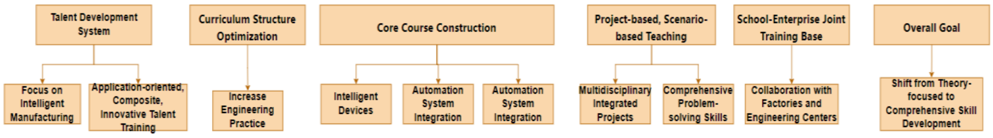

Figure 2. Reform Pathway Diagram

5 Reform effect evaluation

5.1 Theoretical level assessment

To evaluate the effectiveness of the reform, two main aspects were considered at the theoretical level. First, students' ability to apply their professional knowledge to solve real-world engineering problems was assessed through eight open-ended comprehensive application questions covering various modules. Second, a closed-book examination method was used to evaluate their mastery of fundamental professional knowledge, including multiple-choice questions, fill-in-the-blank questions, and calculation questions. The target was to achieve scores above 80% of the total points. These assessments complemented each other and revealed that students in this major improved by approximately 30% in their theoretical and practical abilities after the reform, meeting the expected goals of talent development, as shown in Table 1.

Table 1. Comparison of Student Theoretical Assessment Scores Before and After the Reform

Assessment Stage	Number of Participants	Average Score	Pass Rate	Excellence Rate
Before Reform	150	68	76%	12%
After Reform	160	87	93%	37%

5.2 Practical skills assessment

Practical skills assessment is conducted through on-site evaluations, featuring assessment teams comprising both qualified teachers and engineering professionals from companies. These teams directly observe students' performance during practical training and internships, evaluating hands-on operation skills, teamwork, problem-solving abilities, and time management, among other aspects. Assessment areas include equipment and system debugging, fault analysis, and teamwork, each with clear grading criteria. Scores above 90 are considered excellent. On-site assessments provide a tangible evaluation of students' comprehensive problem-solving abilities in real production environments, reflecting teaching effectiveness. Results from a recent assessment show that over 85% of students demonstrated good or excellent practical skills, indicating a notable improvement in teaching effectiveness. Future plans include expanding practical teaching, strengthening dual-teacher guidance, and enhancing students' engineering practice and application abilities, as shown in Figure 3.

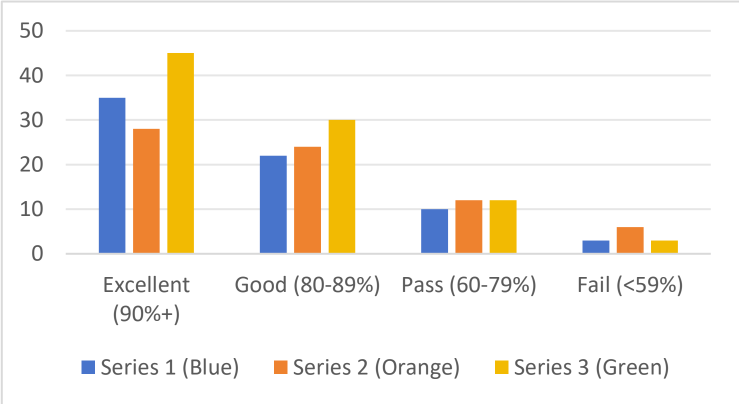

Figure 3. Student Scores in Different Assessment Areas

5.3 Employment quality assessment

In order to assess the impact of the reforms in professional education on the quality of graduates' employment, we established core assessment indicators and conducted statistical analyses. Firstly, we examined the employment rate by gathering data through questionnaires and interviews with recent graduates. The results indicated that the employment rate for this year's graduates stands at 96%, aligning with our anticipated target. Secondly, we evaluated employer satisfaction by conducting surveys through online questionnaires and telephone communications with employers who hired graduates from our program. Impressively, 83% of employers regarded our graduates as possessing excellent professional knowledge and application skills, with 92% expressing overall satisfaction. Thirdly, we analyzed the rate of graduates pursuing further education abroad within three years of graduation. Over the past three years, a total of 92 students from our program pursued postgraduate studies abroad, constituting 14.7% of the total number of graduates. This figure exceeded an average study abroad rate of 12% within three years, as illustrated in Table 2.

Table 2. Study Abroad Rate Statistics

Year	Number of Graduates Studying Abroad	Total Number of Graduates	Study Abroad Rate
2021	25	170	14.7%
2022	30	190	15.8%
2023	37	200	18.5%

Lastly, we examined the entrepreneurial outcomes of our graduates. Our surveys and statistics revealed that, in the last three years, 32 graduates successfully embarked on technology-based entrepreneurial ventures, yielding an entrepreneurship rate of 5.1%. These indicators collectively signify that the reforms in our talent development model have effectively met our anticipated objectives, substantially bolstering the employability and competitiveness of our graduates in the job market.

6 Conclusion

Our practical reform efforts in intelligent manufacturing, particularly in curriculum design and teaching methods for mechanical manufacturing and automation programs, have yielded significant success. Key takeaways include the need for a flexible curriculum system that aligns with industry tech trends, a shift in teaching philosophy focusing on problem-solving and engineering awareness, and the importance of top-level design and step-by-step implementation. Establishing an assessment system that monitors knowledge acquisition, practical skills, and graduate employment quality is vital. This initiative highlights the value of collaboration with industry, effective process management, and dynamic assessments in improving professional education. It's a potent approach to address industrial shifts and meet evolving societal and economic needs.

Project Information

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