Exploration of Teaching Reform Paths for the "Mechanical Manufacturing Equipment Design"

Zhihui Xing*, Na Wang, Lianzhou Yu, Xiaolin Zhang, Lina Cong
School of Mechanical Engineering, Shenyang Urban Construction University, Shenyang, Liaoning, China
**Corresponding Author*

Abstract: This paper explores the teaching reforms of the Mechanical Manufacturing Equipment Design course, focusing on the current teaching situation, reform pathways, and implementation outcomes. The existing teaching model faces challenges such as insufficient student initiative in independent learning, limited depth of teacher-student interaction, and a singular assessment method. To address these issues, the course has restructured its teaching system by integrating theoretical instruction, practical training, and innovation modules. It incorporates case-based teaching and online-offline hybrid models, while strengthening the connection between engineering practice and ideological-political education. The reform emphasizes enhancing student competencies as the core objective, utilizing project-driven learning, competition involvement, and industry-academia collaboration to stimulate innovative thinking and practical abilities. This initiative provides a referential practical case for the reform of mechanical engineering courses under the framework of engineering education accreditation.

Keywords: Mechanical Manufacturing Equipment Design; Process Evaluation; Engineering Practical Ability; Teaching Reform

1. Introduction

With the advancement of emerging engineering education and engineering education accreditation, the teaching of mechanical engineering specialized courses must confront challenges inherent in traditional models, such as the disconnection between theory and practice and insufficient cultivation of students' innovative abilities[1]. As a core course in mechanical engineering, the teaching reform of Mechanical Manufacturing Equipment Design is significant for cultivating high-quality application-oriented talents. Current teaching of this course faces prominent issues, including passive student learning and a singular assessment method, which struggle to meet the demands for core engineering literacy in the era of intelligent manufacturing. Based on the "Five Practical Educations" concept of Shenyang Urban Construction University, this paper explores a competency-oriented course reform path by reconstructing teaching content, innovating teaching models, and optimizing evaluation mechanisms. It aims to transform knowledge impartation into literacy cultivation, providing a reference for course construction in similar institutions.

2. Current State of Course Teaching

2.1 Lack of Motivation for Self-Directed Learning among Students Currently, most students are in a state of passively receiving knowledge, showing poor self-directed learning ability[2-3]. This phenomenon is particularly noteworthy in current teaching of engineering specialized courses. Specifically, during classroom teaching, students are primarily in a passive acceptance state, learning what the teacher instructs without proactive thinking or in-depth exploration. After class, students are mostly confined to completing assignments given by the teacher; some even require assistance from others to complete tasks. According to questionnaire survey results from 50 students at the end of the semester, only about 68% of students actively participated in classroom learning, while 24% rarely participated actively, and approximately 8% basically did not participate in classroom learning. This data further reflects an overall deficiency in students' sense of agency and autonomy in learning.

2.2 Insufficient Depth and Frequency of Teacher-Student Interaction

In the current teaching process of this course, interaction between teachers and students is often limited to one-way knowledge transmission. Teachers typically adhere strictly to pre-set teaching plans for instruction, while students remain in a passive acceptance state. Classroom questioning is predominantly initiated by teachers, with students merely responding passively and completing assigned tasks after class. Under this model, the lack of in-depth two-way communication and discussion makes it difficult for teachers to fully grasp students' learning progress and genuine challenges[4-5]. Consequently, students often fail to receive timely and effective guidance when encountering difficulties. This one-way approach tends to formalize teacher-student interaction—for instance, teachers may frequently use closed-ended questions like "Is that right?" or "Isn't it?", which appear interactive but lack critical thinking depth. To address this issue, the concept of "two-way communication" can be incorporated by designing high-quality questions, encouraging students to raise inquiries, and promoting collaborative learning. This approach would enable teachers to better diagnose learning needs while allowing students to resolve doubts proactively in the interaction process.

2.3 Singular Assessment Methods and Lack of Competency Orientation

The current assessment approach for the Mechanical Manufacturing Equipment Design course continues to adhere to the traditional dual structure of "regular assessment add final assessment." This model over relies on scores to measure students' mastery of theoretical knowledge, resulting in a narrow evaluation dimension. The assessment content is largely limited to classroom attendance, homework, and final examinations, making it difficult to comprehensively and authentically reflect students' practical abilities in engineering design and practice, such as innovative design capabilities for mechanical equipment, analytical skills for complex engineering problems, and the ability to propose effective solutions [6-7]. This misalignment causes a disconnect between assessment outcomes and the core objective of cultivating students' comprehensive ability to solve complex engineering problems. Some students may resort to last-minute cramming rather than deeply understanding and applying knowledge. Therefore, exploring and establishing a process-oriented, diversified assessment mechanism that more accurately evaluates students' comprehensive competencies and innovative thinking is crucial for enhancing course teaching quality and aligning with engineering education accreditation requirements.

3. Specific Implementation Plans and Pathways for Course Reform and Construction

The course reform primarily focuses on transforming classroom teaching formats, supplemented by formative assessments and innovative classroom development. It aims to cultivate applied skilled talents, using intelligent systems in the modern mechanical engineering industry as a carrier, combined with teaching practice and training objectives. The reform emphasizes capacity enhancement and quality training, fostering students' initiative in integrating theory with practice while nurturing innovative thinking and stimulating professional interest. Specific measures include the following aspects.

3.1 Development of Teaching Materials

During the theoretical teaching of Mechanical Manufacturing Equipment Design, most sessions are conducted in multimedia classrooms. Throughout this process, emphasis is placed on each lesson's instructional design, implementation, and feedback. Accordingly, resources such as the teaching syllabus, lesson plans, multimedia courseware, and workbooks have been meticulously designed and revised. For example, in developing lesson plans, attention is given to the "new lesson introduction" section, where simple, familiar cases are used to introduce the lesson's content. In the "new lesson delivery" part, key and difficult points are distinguished, explained step by step in a clear manner to impart theoretical knowledge. In the "lesson summary" and "homework" sections, key points are highlighted to cultivate students' abilities to analyze and solve problems.

3.2 In-Depth Classroom Teaching

In classroom teaching, a combination of multimedia and blackboard writing is used for instruction. Through multimedia, videos, animations, and other materials are played to help students understand complex engineering issues, thereby enhancing their learning enthusiasm and efficiency. Meanwhile, appropriate blackboard writing is used to emphasize key and difficult points, clarifying the knowledge framework to genuinely improve teaching quality[8-9].

Additionally, during routine offline lectures, students' note-taking is emphasized. At the beginning of each semester, a "Mechanical Manufacturing Equipment Design—Most Beautiful Notes" activity notice is issued, and at the end of the semester, all class notes are evaluated to select those that are carefully recorded, neatly written, and reflective of post-class thinking. This process effectively focuses students' attention, deepens understanding of knowledge, aids in review, trains thinking, and becomes a unique learning asset, serving as an important long-term learning strategy and tool for students.

3.3 Strengthening Ideological and Political Education

In both the preparation of teaching materials and daily instruction, ideological and political education is consistently emphasized. Students' engineering ethics education is continuously enhanced, fostering a spirit of meticulous craftsmanship and striving for excellence. Students are guided to maintain patriotic sentiment, concern for the nation and society, and to aspire to great ideals while becoming strivers of the era. Meanwhile, a bridge for communication between students and teachers is actively built, creating avenues for emotional expression. For example, after completing sections on the development trends of mechanical manufacturing equipment and the current state of China's equipment development, students feel inspired. They recognize the continuous improvement of China's independent innovation capabilities, the emergence of products with independent intellectual property rights, and the future shift of Chinese manufacturing from a "large manufacturing country" to a "smart manufacturing country." Based on this, assignments such as "The Nation's Equipment and I" are given, prompting students to express their feelings. This ignites a sense of national mission and responsibility in contributing through technology, effectively cultivating mechanical engineering talents with both moral integrity and professional competence.

As illustrated, one student's assignment expressed: "Through the Zhuhai Airshow, I witnessed the tremendous progress of China's technology and defense industry—the most direct way to see this, especially for those who have watched videos of early airshows.

As a third-year university student, seeing the significant advances in Chinese aerospace constantly motivates us to move forward. Although the university offers courses like 3D modeling with SW, CAD drafting, and mechanical course, I feel I've only scratched the surface. To research aircraft, more effort is needed. No matter where I work in the future, I will shine in my position, contributing my share to the nation's development."

3.4 Online Teaching Development

Based on the Superstar Learning Pass platform, the blended online and offline teaching model effectively expands the teaching space and time, promotes teacher-student interaction, and enables precision teaching through systematic course design and functional integration. Teachers can create a dedicated course space on the Superstar Learning Pass, where they systematically upload and categorize various learning materials—such as syllabi, courseware, recorded micro-lectures, and supplementary literature—into the platform's cloud storage.

This provides students with rich resources for independent learning. Before class, instructors can release pre-class tests or surveys to help students identify key learning points. Simultaneously, teachers can use the platform's data to understand students' preview situations, thereby informing the design of offline classroom sessions. During the in-person class, teachers can seamlessly display PPTs using the platform's screen projection function and incorporate interactive tools like random selection, quick response, thematic discussions, and in-class exercises. These features effectively capture student attention and increase classroom participation. After class, teachers can assign homework, initiate online discussions, or publish chapter tests through the platform. Students submit their assignments on time and can continue to discuss difficult questions with peers or instructors in the discussion forums.

The Superstar Learning Pass platform

automatically records comprehensive data on student participation in various activities, such as video viewing progress, homework completion status, quiz scores, and discussion forum contributions. This data provides an objective basis for teachers to implement process evaluation, making teaching assessment more scientific and comprehensive, and also supports continuous instructional improvement. This blended linkage teaching model not only enriches teaching methods but also effectively enhances the overall teaching outcomes[10].

Furthermore, by developing teaching assistance platforms, a virtual-real integrated teaching model is achieved. This method provides students with diverse teaching resources, enabling personalized and diversified classroom teaching formats. Through simulation models, animations, and video explanations, students can gain a practical understanding of machine tools, including their appearance, structure, working principles, operation, and maintenance. This deepens students' mastery of theoretical knowledge and enhances their scientific thinking and problem-solving abilities.

3.5 Development of Practical Teaching

In terms of teaching content, instructors have fundamentally moved beyond the limitations of traditional textbooks, establishing a dynamically updated knowledge system that deeply integrates industry, academia, and research. In addition to imparting core theoretical knowledge, there is a conscious effort to introduce new technologies, processes, and equipment topics reflecting industry frontiers, such as intelligent manufacturing, green manufacturing, industrial robots, and digital twins. For instance, when explaining machine tool design, the current development status of intelligent machine tools is incorporated, analyzing their latest technological breakthroughs in high precision, high efficiency, and adaptive control. Part of this content stems from the instructors' latest research project outcomes, technical problem-solving cases from industry collaborations, as well as authoritative academic journals and industry reports, ensuring that the knowledge students acquire keeps pace with—or even stays ahead of—industry developments.

In teaching methodology, the course actively implements Project-Based Learning (PBL), closely coupling theoretical learning with innovative practice[11]. Instructors design a series of "micro-projects" or comprehensive design tasks derived from real industrial scenarios. For example, students might be tasked with designing an automated processing unit for a specific automotive component, requiring them to complete the entire process from process analysis and equipment selection to structural design and solution optimization. During this process, students are encouraged to form teams and collaboratively solve problems through group discussions, research, software simulation (using tools like CAD/CAE/CAM), and model building. This approach simulates the real working environment of engineers, effectively fostering students' innovative awareness, comprehensive design capabilities, and team spirit.

The course particularly emphasizes leveraging high-level academic competitions to build a practice-oriented teaching system that integrates competition with instruction. Competitions such as the "National University Engineering Training Integration Ability Competition" and the "Mechanical Innovation Design Competition" are organically incorporated into the course teaching. Instructors guide students to apply knowledge learned in class—such as mechanical principles, design methods, and control technologies—to the conceptualization, design, and creation of specific competition entries like intelligent equipment or environmental protection devices. The preparation process for these competitions provides the ultimate training for students' hands-on and practical engineering abilities, while significantly stimulating their innovative enthusiasm and potential for solving complex engineering problems. Universities typically provide necessary venues, equipment, funding, and assign instructors with engineering experience for specialized guidance to support such activities.

To support the aforementioned reforms, the course evaluation mechanism has shifted from a sole reliance on final written exams to a focus on the entire learning process and diversified assessment methods. The final grade may comprise multiple dimensions, including the quality of project reports, participation and outcomes in competitions, performance in experimental operations, team collaboration, and results from the final theoretical exam. This "whole-process, diversified" evaluation system more objectively reflects students' knowledge application ability, practical innovation capability, and comprehensive quality, guiding the focus of learning from "memorizing knowledge points" to "enhancing genuine capabilities".

Through the teaching model that organically integrates cutting-edge expertise, project practice, and innovation competitions, the "Mechanical Manufacturing Equipment Design" course effectively combines knowledge impartation, ability cultivation, and quality enhancement, laying a solid foundation for students to meet the future development demands of the intelligent manufacturing field.

4. Conclusion

Against the backdrop of Emerging Engineering Education and engineering education accreditation, the teaching reform of the Mechanical Manufacturing Equipment Design course has taken the fundamental transformation of classroom teaching models as its core driver. With the overarching goal of systematically achieving students' knowledge internalization, competency development, and literacy enhancement, the curriculum system has been restructured. The reform aims to construct a new integrated course architecture that organically combines and deeply intertwines the theoretical teaching system, practical teaching system, and innovative teaching modules. By introducing interactive approaches such as case-based teaching and project-driven learning, and actively developing innovative classrooms, the reform seeks to stimulate students' initiative for active exploration and effectively enhance their professional skills and hands-on practical abilities.

Acknowledgments

This paper is supported by the 2024 University-Level High-Quality Course "Mechanical Manufacturing Equipment Design" of Shenyang Urban Construction University, and the 2025 Liaoning Provincial Social Science Planning Fund Project "Research on Teaching Reform Paths of Mechanical Engineering Courses Based on Engineering Education Accreditation".

References

[1] Hu, F. Y., Xu, J. C., & Xie, J. (2025). Research status on dust deposition mechanism and cleaning technology for photovoltaic module surfaces. Acta Energiae Solaris Sinica, 46(10), 197-208.

[2] Su, T. W. (2025). Key technologies and refined management measures for improving power generation efficiency in photovoltaic power station operation and maintenance. Electronic Components and Information Technology, 9(5), 55-57.

[3] Liu, M., & Zhan, J. Q. (2024). Exploration of teaching reform in mechanical courses based on the combination of VR technology and 3D printing: Taking 'Mechanical Manufacturing Equipment Design' as an example. Education Teaching Forum, (31), 89-92. 4.

[4] Lyu, D. T. (2024). Intelligent detection technology and applications. Northwest University Press.

[5] Jiang, Z. G., Gong, Q. S., & Ke, C. (2024). Equipment remanufacturing technology and typical applications. Chemical Industry Press.

[6] Huang, B. Y., Sun, F. Y., Jian, Z. A., et al. (2024). Design of an image recognition-based amphibious cleaning robot for solar power generation. Plant Engineering, (2), 29-32.

[7] Zhu, D. M., & Liu, G. Y. (2024). Application of flipped classroom teaching method in mechanical manufacturing equipment design. China Modern Educational Equipment, (7), 118-120, 130.

[8] Gong, H. Z., Ye, J., Wang, Y. P., et al. (2024). Research on motion path planning of distributed cleaning robot for rooftop photovoltaic power plant. Manufacturing & Upgrading Today, (1), 1-3.

[9] Yang, H. R., Sun, X. W., Li, S. S., et al. (2023). Discussion on integrating curriculum ideology and politics into engineering professional courses under the background of emerging engineering education: Taking the course 'Mechanical Manufacturing Equipment Design' as an example. Education Teaching Forum, (52), 133-136.

[10] Wang, J. J., Wang, J. X., Zhang, C., et al. (2023). Research on dynamic path planning method for cleaning robots in complex terrain of photovoltaic power stations. Rock Drilling Machinery and Pneumatic Tools, 49(4), 10-18, 27.

[11] Zhang, X. (2023). Establishment of a test question bank management system for 'Mechanical Manufacturing Equipment Design'. Computer Era, (12), 149-152, 157.