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Teaching Reform of the Hydraulic Transmission Course for Enhancing Engineering Practice Competence under the Development of New Quality Productive Forces

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Abstract: With the rapid advancement of new quality productive forces, particularly intelligent manufacturing and automation technologies, the demand for engineering practice competence in hydraulic transmission has increased significantly. However, the traditional teaching model of the Hydraulic Transmission course is no longer sufficient to meet the evolving requirements of talent cultivation. To address existing challenges, including the disconnect between theory and practice, limited instructional approaches, and a monotonous assessment system, this study proposes a teaching reform framework centered on strengthening engineering practice competence under the guidance of new quality productive forces. The reform enhances practical training through project-based learning, virtual simulation technologies, and university–industry collaboration, thereby improving students' abilities in hydraulic system design and fault diagnosis. In addition, diversified teaching approaches, including case-based learning, flipped classrooms, and blended learning, are adopted to promote classroom interaction and strengthen the integration of theoretical knowledge with engineering applications. Furthermore, the assessment system is redesigned by increasing the proportion of practical evaluation and incorporating process-oriented assessment, thereby fostering students' technical proficiency and engineering competence in hydraulic transmission. The proposed reform provides a solid foundation for preparing students to meet the demands of engineering practice in emerging productivity-driven industries.

Keywords: New Quality Productive Forces; Engineering Practice; Hydraulic Transmission; Teaching Reform
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1. Introduction

Hydraulic transmission technology is widely employed in industrial automation, construction machinery, aerospace, and other engineering fields, making it a core course in mechanical engineering education [1,2]. With the ongoing transformation and upgrading of China's manufacturing industry, hydraulic transmission technologies have become increasingly important in emerging sectors driven by new quality productive forces, particularly in high-end equipment manufacturing. Consequently, cultivating engineering practice competence based on hydraulic transmission technology is of great significance for supporting industrial development in the era of new quality productive forces [3]. Beyond serving as a platform for knowledge acquisition, the Hydraulic Transmission course plays a vital role in fostering students' innovation and entrepreneurial capabilities. Through systematic learning, students acquire fundamental knowledge of hydraulic principles, system design methodologies, and practical engineering skills, thereby establishing a solid foundation for future professional development and technological innovation [4].

In recent years, considerable efforts have been devoted to reforming the teaching of hydraulic transmission courses. Wang proposed a multimodal teaching approach integrating university–industry collaboration, engineering-oriented classes, and the incorporation of ideological and political education elements into classroom instruction [5]. Wang et al. explored teaching reform from three aspects: optimizing course content, innovating instructional methods, and improving assessment strategies [6]. Zhou et al. introduced an integrated teaching model focusing on strengthening theoretical foundations, enhancing research-oriented learning, and emphasizing competency development [7].

Building upon these studies, this paper investigates the reform of hydraulic transmission education aimed at strengthening engineering practice competence under the guidance of new quality productive forces. The objective is to explore innovative teaching strategies that better align educational practices with real-world engineering requirements and industrial applications. The findings of this study are expected to promote the deep integration of engineering practice and hydraulic technology education, contribute to the cultivation of high-quality hydraulic engineering professionals, and provide valuable references for curriculum innovation and pedagogical improvement. Furthermore, the proposed reform lays a solid foundation for integrating hydraulic transmission education with engineering practice in the context of emerging engineering disciplines and new quality productive forces.

2. Current Status and Challenges of Hydraulic Transmission Education

2.1 Characteristics of the Traditional Teaching Model

At present, the Hydraulic Transmission course is predominantly delivered through a traditional teaching model characterized by theory-oriented classroom instruction supplemented by basic experimental verification. The theoretical component mainly relies on lecture-based, instructor-centered teaching, focusing on classical topics such as the structure of hydraulic components and the operating principles of fundamental hydraulic circuits. Together with textbook examples and problem-solving exercises, this approach helps students establish a foundational theoretical framework. However, the instructional content and delivery methods are relatively homogeneous and often lack integration with practical engineering scenarios.

Laboratory teaching is further constrained by limitations in equipment availability, operational costs, and safety requirements. As a result, experimental activities are generally restricted to fundamental verification experiments, such as basic hydraulic circuit assembly, pressure regulation of relief valves, and flow control using throttle valves. Although these experiments reinforce theoretical concepts, they provide limited opportunities for addressing complex engineering problems or developing system-level design skills. This teaching model places greater emphasis on theoretical knowledge and fundamental principles than on practical application and engineering implementation. Consequently, while students acquire essential theoretical knowledge, they often exhibit deficiencies in system integration capability, engineering thinking, and problem-solving skills in real-world contexts. These limitations hinder the development of the engineering practice competence required by modern industry.

2.2 Existing Problems

(1) Disconnect Between Theory and Practice: The current Hydraulic Transmission curriculum places excessive emphasis on theoretical instruction while providing insufficient integration with practical applications. Statistics show that theoretical lectures accounts for roughly 75% of the total teaching hours, while experimental operations and engineering case analysis only account for 25%, forming a prominent imbalance between theory and practice. For example, when introducing the operating principles of hydraulic components, teaching is often limited to explaining their structures and functions, with little connection to experimental activities or engineering case studies. As a result, students frequently encounter difficulties in understanding abstract concepts and struggle to effectively apply theoretical knowledge to real-world engineering problems.

(2) Limited Diversity in Teaching Methods: The existing teaching approach exhibits a high degree of homogeneity and remains largely constrained by traditional instructional frameworks. Classroom activities are predominantly centered on one-way knowledge transmission, with theoretical lectures serving as the primary mode of instruction. Under this teacher-centered

model, students often assume a passive learning role, resulting in low levels of classroom engagement. Consequently, students' enthusiasm for exploration, motivation for self-directed learning, and ability to develop systematic engineering thinking and innovative practical skills are not effectively cultivated.

(3) Inadequate Assessment System: The current assessment framework demonstrates a pronounced emphasis on theoretical knowledge at the expense of practical competence. Evaluation is primarily based on closed-book written examinations, which typically assess students' memorization and calculation abilities through question formats such as multiple-choice and short-answer questions related to hydraulic component parameters and circuit operating principles. In contrast, the assessment of practical skills remains limited in both scope and weighting, generally accounting for only 10%–30% of the overall course grade. As a result, students' engineering practice capabilities and problem-solving skills are not comprehensively evaluated.

3. Teaching Reform Strategies and Measures

3.1 Strengthening Practical Teaching

(1) Project-Based Learning: Project-based learning should be introduced to organize teaching activities around real engineering problems. Students are encouraged to work in teams to design, assemble, and commission hydraulic systems. Representative projects may include hydraulic manipulators and hydraulic systems for automated production lines. Through participation in these engineering-oriented projects, students can gain a deeper understanding of hydraulic transmission principles and their practical applications while enhancing their problem-solving and teamwork skills.

(2) Virtual Simulation Technology: Virtual simulation platforms can be established using hydraulic simulation software such as Automation Studio and AMESim. Within these virtual environments, students can model and analyze the operation of hydraulic systems under various working conditions. This approach enables risk-free operational training while alleviating limitations caused by insufficient laboratory equipment. Repeated simulation exercises allow students to investigate system behavior, diagnose faults, and develop engineering problem-solving capabilities.

(3) University–Industry Collaboration: Close cooperation between universities and enterprises should be established to provide students with industry-oriented practical experiences. Through participation in industrial projects, such as hydraulic system design and commissioning, students gain exposure to real engineering environments. In addition, visits to industrial production facilities and guidance from practicing engineers enable students to engage in hydraulic system optimization tasks, thereby facilitating the integration of theoretical knowledge with engineering practice.

3.2 Diversified Teaching Methods

(1) Case-Based Learning: Case-based teaching can be employed to connect theoretical knowledge with real engineering applications. By analyzing practical engineering cases, students are able to better understand and apply concepts learned in class. For example, a hydraulic excavator at a construction site may exhibit symptoms such as slow operation, insufficient bucket force, and abnormal noise during rotation. Such cases transform abstract topics, including hydraulic components, circuit analysis, and fault diagnosis, into tangible engineering problems, thereby strengthening students' engineering thinking and practical problem-solving abilities.

(2) Flipped Classroom: The flipped classroom model shifts knowledge acquisition to the pre-class stage and reserves classroom time for discussion, demonstration, and problem-solving activities. For instance, topics such as directional control circuit design and fault diagnosis can be assigned as pre-class learning tasks. Instructors may prepare micro-lecture videos covering the structure and operating principles of solenoid directional valves and directional control circuits. During class, student groups present demonstrations and solutions, followed by instructor feedback and peer evaluation. This approach not only deepens students' understanding of hydraulic transmission concepts but also provides opportunities to engage with authentic engineering scenarios.

(3) Blended Learning: Blended learning integrates online and offline instructional activities to improve learning effectiveness. Before class, online micro-courses, quizzes, and virtual simulation exercises help students acquire foundational knowledge and establish a theoretical framework. During class, online tools such as real-time polling and collaborative platforms can be combined with offline laboratory experiments, case analyses, and instructor guidance to promote active learning and practical skill development. After class, AI-assisted feedback systems can provide personalized learning support, while open laboratory

sessions and industrial field visits further enhance students' engineering innovation and application capabilities.

3.3 Reform of the Assessment System

(1) Increasing the Weight of Practical Assessment: To better reflect engineering competence, practical assessment should account for more than 50% of the final course grade. The evaluation should focus on key engineering abilities, including hydraulic system design, commissioning, and fault diagnosis. Basic technical skills (approximately 10% or more) may be assessed through standardized operations such as the disassembly and assembly of hydraulic components (e.g., gear pumps and relief valves) and the construction of fundamental hydraulic circuits, including directional and pressure-control circuits. Comprehensive application abilities (approximately 15% or more) can be evaluated through independent analysis of practical hydraulic system faults or the development of energy-saving improvement schemes for engineering machinery hydraulic systems. Innovation capability (approximately 25% or more) may be assessed through interdisciplinary design projects, such as PLC-based hydraulic control systems, or participation in engineering innovation competitions.

(2) Process-Oriented Assessment: A multidimensional assessment framework should be adopted to evaluate students' overall performance throughout the learning process. Pre-class preparation (10%) may be assessed through task completion rates and performance on online learning platforms such as Moodle or Chaoxing, Classroom participation (15%) can be evaluated using interactive teaching tools to monitor student engagement, questioning behavior, and group discussion activities. Laboratory performance (25%) should be assessed based on operational accuracy, procedural compliance, and experimental outcomes, using both platform-generated data and instructor observation records. Practical innovation activities (25%) may be evaluated through group projects, considering factors such as project progress, originality of proposed solutions, and team collaboration efficiency. Finally, a closed-book theoretical examination (25%) should be retained to assess students' mastery of fundamental concepts and principles.

4. Conclusions

This study addressed several limitations of the traditional Hydraulic Transmission curriculum, including the disconnect between theory and practice, the lack of diversity in teaching methods, and the overreliance on theory-oriented assessment. In response to the emerging demands of new quality productive forces, a teaching reform framework centered on strengthening engineering practice competence was proposed.

The proposed reforms include optimizing practical teaching through project-based learning, virtual simulation technologies, and university–industry collaboration; implementing diversified instructional approaches such as case-based learning, flipped classrooms, and blended learning; and redesigning the assessment system by increasing the proportion of practical evaluation and incorporating process-oriented assessment. These measures effectively enhance students' abilities in practical problem-solving, engineering thinking, and innovative practice.

Compared with traditional teaching models, the proposed framework better integrates theoretical learning with engineering applications and promotes the coordinated development of knowledge acquisition and practical competence. Through the combination of virtual and physical learning environments, as well as close collaboration between academia and industry, students are provided with learning experiences that more closely reflect real engineering contexts. As a result, their capability to analyze and solve complex engineering problems is significantly strengthened. Future work should further explore the integration of emerging technologies, such as artificial intelligence, digital twins, and intelligent manufacturing systems, into hydraulic transmission education. Continuous optimization of curriculum content, teaching methodologies, and assessment mechanisms will contribute to the cultivation of high-quality engineering professionals capable of meeting the technological and industrial demands associated with the development of new quality productive forces.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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