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Research on the teaching reform of fluid mechanics and hydraulic transmission under the background of engineering education certification

Jicai Yin*, Bingchuan Bian, Chonggang Ren, Peng Guo, Xuehu Xie

School of Mechanical Engineering, Taishan University, Yingbin Road, Tai'an, 271000, China
**Corresponding author: jcyin@tsu.edu.cn*

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Abstract: With the rapid development of science and technology, the engineering education in our country must be adjusted accordingly. As a critical professional course for mechanical engineering, "Fluid Mechanics and Hydraulic Transmission" plays a vital role in industrial power transmission and control technology. In addition, it is of great significance to the training of applied talents in local colleges and universities. This paper investigates the stringent requirements for the composition, credit allocation, practical implementation, and faculty qualifications in the "Fluid Mechanics and Hydraulic Transmission" course required by engineering education accreditation. It identifies existing shortcomings in the course's delivery and subsequently proposes relevant solutions and measures. These recommendations aim to enhance the teaching of "Fluid Mechanics and Hydraulic Transmission" in local colleges and universities, serving as valuable guidance and reference.

1. Introduction

In 2016, China became the 18th member of the "Washington Agreement"[1]. This milestone indicated that the level of engineering education in China has been recognized internationally, which has facilitated the alignment of Chinese engineering education with global standards [2]. Joining the Washington Agreement has accelerated the reform and improvement of China's higher engineering education system. It has fostered the integration of practical and theoretical aspects of engineering education within the country and enhanced collaboration between academic institutions and industry [2]. These developments are crucial for training engineers who meet international standards and industry requirements, thereby further boosting China's competitiveness in the global engineering technology arena.

At the same time, joining the Washington Agreement will also provide more international opportunities and establish standards for the quality evaluation and certification of engineering education in China. This will be instrumental in enhancing both the level and reputation of engineering education in our country. Additionally, this action is expected to better meet the needs

of both domestic and international markets for engineering and technical talents. With our country becoming the 18th member of the "Washington Agreement", the internationalization of China's engineering education has been solidified. This development is of great significance in promoting the advancement and progress of China's engineering sector.

Engineering education certification represents a modern international system designed to assure the quality of engineering education quality. It also plays a crucial role in facilitating the international mutual recognition of engineering education and qualifications for engineers. Given the disparities in the training of application-oriented undergraduate talents, engineering education certification emerges as an ideal starting point for local colleges and universities to enhance discipline construction and improve the quality of undergraduate talent training. The benefits of engineering education certification for local institutions extend beyond mere adherence to standards. It enables them to identify a fundamental pathway and adhere to the principles of training application-oriented talents.

The core of the engineering education professional certification standard is the Outcome-Based Education (OBE) education concept, which is student-centered, output oriented, and focused on continuous improvement. This teaching paradigm encourages the formulation of talent training objectives that align with both the institution's positioning and industry development, fully considering the demands of the workforce. Subsequently, graduation requirements for the relevant majors are developed in conjunction with the standards of engineering certification, and a curriculum system is established based on these requirements. By integrating innovative core courses and practical teaching platforms, a talent training model that emphasizes "student orientation and the development of innovative and entrepreneurial skills" is established. This approach gradually enhances the quality of talent training and increases the professional visibility of the programs.

Engineering education certification has strict requirements for corresponding course composition, credit proportion, practice conditions and teaching staff, which brings great impact to the traditional undergraduate talent training. Local undergraduate colleges and universities committed to improving the quality of talent training through engineering education certification must make major adjustments.

2. The introduction of the Fluid Mechanics and Hydraulic Transmission

Fluid Mechanics and Hydraulic Transmission is a crucial professional course for mechanical engineering majors. This course demands that students master the essential principles of fluid mechanics and gain a comprehensive understanding of the structure, principles, performance, and application of fundamental hydraulic components and typical hydraulic circuits. In addition, it requires students to learn the design methods of hydraulic control systems. Moreover, students are expected to tackle complex engineering challenges involving hydraulic systems in the field of mechanical engineering, utilizing the knowledge they have acquired. Through this course, students gain an initial appreciation for the development of hydraulic transmission in China, covering its basic theories, application fields, common key technologies in related areas, and the technological constraints that impede the country's scientific and technological advancement. Additionally, the course aims to enhance students' sense of mission and responsibility, as well as their patriotic sentiments.

The course content of Fluid Mechanics and Hydraulic Transmission primarily encompasses an introduction, the foundation of fluid mechanics, oil hydraulic pump, hydraulic cylinder, hydraulic

valve, auxiliary components, basic hydraulic circuits, typical hydraulic systems, and the design of hydraulic systems. This course is delivered mainly through classroom instruction, which is enhanced by modern information technology and the use of advanced teaching concepts. This approach enables students to master the basic principles of fluid mechanics and to understand the structure, principles, performance, and applications of basic hydraulic components and typical hydraulic circuits. Additionally, students will learn the design methodologies of hydraulic control system.

3. The problem of course teaching

"Fluid Mechanics and Hydraulic Transmission" is one of the most important professional course of mechanical engineering majors, and its curriculum is continually undergoing reforms. The effective implementation of high-quality teaching for this course remains a central focus of our discussions. At present, the problems in the teaching of "Fluid Mechanics and Hydraulic Transmission" in local undergraduate universities are as follows.

(1) The teaching method of the course is simple

The traditional teaching mode of "Fluid Mechanics and Hydraulic Transmission" primarily involves classroom-based instruction [3]. However, with societal advancements, technologies such as PowerPoint presentations, animations, and virtual reality (VR) are increasingly being utilized to enhance students' ability to assimilate new knowledge. Given the practical nature of Fluid Mechanics and Hydraulic Transmission, the conventional teaching approach is often disconnected from real-world applications and does not adequately align with the current model for training applied talents.

(2) Practical teaching is seriously insufficient [4]

The practical teaching of "Fluid Mechanics and Hydraulic Transmission" requires substantial hydraulic equipment, which poses a challenge for application-oriented colleges and universities that often lack sufficient funding to develop these resources. Additionally, hydraulic equipment tends to be noisy and operates in environments with poor conditions, strong odors, and high risks. Consequently, many general colleges and universities are hesitant to invest heavily in the infrastructure required for such practical equipment. This environment can also deter students from pursuing careers in related fields.

(3) Students have little interest in learning

The knowledge of fluid mechanics in Fluid Mechanics and Hydraulic Transmission requires a solid foundation of mathematics and physics. However, many students have little interest in mathematics and physics, which leads to low interest in this course. The knowledge related to hydraulic transmission involves the structural principle of hydraulic pump, hydraulic cylinder, hydraulic valve and auxiliary components, etc. This part of knowledge is obscure and it is difficult to understand or causing certain confusion to students. Furthermore, understanding this material requires good spatial visualization skills, which are essential for applying theoretical knowledge to practical engineering scenarios. However, students frequently lack this skill set, which further diminishes their interest in the course. This combination of factors contributes to the generally low student engagement with this

(4) Theory is disconnected from practice

In the context of engineering education accreditation, the duration of specialized classes has been significantly reduced. This presents a challenge for courses like "Fluid Mechanics and Hydraulic Transmission," especially when trying to integrate theoretical teaching with practical applications.

The scarcity of practical teaching resources and the time-intensive nature of on-site corporate training exacerbates the situation. Merely providing theoretical instruction is insufficient for developing the practical skills required by applied talents, while solely focusing on practical sessions falls short in fostering their innovative capabilities. Consequently, there is a noticeable disconnect between theoretical teaching and practical application in the instruction of "Fluid Mechanics and Hydraulic Transmission" at local colleges and universities.

4. Course teaching reform process

In response to the aforementioned issues in the teaching of "Fluid Mechanics and Hydraulic Transmission," this course integrates the unique characteristics of the subject and implements a teaching reform from several perspectives. These reforms aim to address the difficulties of combining theoretical instruction with practical application and enhance the overall educational effectiveness in this field.

(1) Student-centered

This course adopts a student-centered educational approach in accordance with the principles of engineering education accreditation. The graduation requirements that correspond to the course objectives are aligned with the training goals of the talent development program. Specifically, the course objectives for "Fluid Mechanics and Hydraulic Transmission" satisfy these relevant graduation requirements. The implementation of course teaching and assessment processes are fully aligned with these objectives, with the primary goal of equipping students to solve complex engineering problems in the field of mechanical engineering. The course is explicitly designed to meet the needs of related industries and integrates practical engineering challenges from the field to enhance relevance and applicability.

The implementation of the curriculum teaching process pays attention to the subjective initiative of students and employs a variety of methods, such as flipped classrooms, task-driven learning, and group discussions, to fully encourage student participation in the learning process. Attention is given to the students' learning experience through multiple questionnaires administered during the course. These surveys provide real-time feedback on students' learning status and their mastery of various knowledge points, allowing for timely improvements and revisions to be made in the implementation of subsequent courses.

(2) Oriented to engineering application

In the context of engineering education certification, the training of applied talents should be tailored to specific industries and fields. Therefore, the development of these talents must be steered by practical engineering applications relevant to their fields. It is essential to incorporate practical engineering case studies into classroom teaching of "Fluid Mechanics and Hydraulic Transmission". This approach nurtures the ability of applied professionals to address complex engineering challenges effectively.

This course uses practical engineering problems as an introduction, effectively stimulating students' enthusiasm for learning and enabling them to recognize the application relevance of the course content in real-world engineering contexts. By substituting theoretical problems with practical ones, it promotes not only the development of students' problem-solving skills but also enhances their logical thinking. Practical engineering cases intertwined with the course's key knowledge points deepen students' grasp of fundamental concepts. The course assessment, oriented towards related industries, emphasizes practical engineering applications to underscore the training of relevant skills.

(3) The aim is to cultivate application-oriented talents

This course is designed with a focus on cultivating application-oriented talents, emphasizing the development of students' innovative and practical skills. Centered around the instruction of "Fluid Mechanics and Hydraulic Transmission," it enables students to acquire a robust foundation in professional theoretical knowledge through diverse methods. The course employs a pedagogical strategy that progresses from basic to advanced levels, using practical engineering application cases to enhance students' innovative capacities. Employing a systems-component-systems approach, it aims to instill systems engineering thinking in the students. Furthermore, project-based teaching methods are utilized to improve students' teamwork and hands-on practical abilities.

(4) Adhere to the moral cultivation of people as the fundamental task

This course is committed to the core mission of fostering moral values and personal development. By delving into the ideological and political dimensions inherent in topics such as industry development, industrial transformation, national policies, national strategies, and notable figures in the field, it integrates these elements thoroughly into both the instruction and assessment aspects of the course. This approach guides students to develop a proper worldview, life perspective, and value system, thereby enhancing their sense of social responsibility and cultivating patriotic sentiments.

(5) Make full use of modern information technology

The course design, both in its teaching process and assessment components, leverages modern information technology extensively. The classroom teaching process combines the advantages of the traditional teaching process, makes full use of the combination of theory, virtual and reality, and adopts multiple means and methods to enhance the students' learning experience. Given the limited classroom hours available for Fluid Mechanics and Hydraulic Transmission within the framework of engineering education accreditation, this course makes full use of tools such as Learning Pass to implement mixed teaching mode. Simpler concepts with less practical application are assigned for self-study outside classroom hours. This allows students to engage in self-directed learning and ensures thorough assessment, which in turn furthers the development of their self-learning capabilities.

(6) Pay attention to the combination of theory and practice

Theoretical courses are structured around a progressive approach that introduces problems and guides students through their resolution. This pedagogy is deeply intertwined with real-world issues, particularly focusing on addressing complex engineering challenges in the field of mechanical engineering. Furthermore, it incorporates the latest research findings and trends in industry development, ensuring that students remain at the cutting edge of their profession. The curriculum is designed to not only provide deep theoretical knowledge but also to enrich students' experience through extensive practical activities. By thoroughly understanding the fundamental principles of Fluid Mechanics and Hydraulic Transmission, students can apply these concepts flexibly in diverse scenarios. The integration of theoretical knowledge with hands-on experimental activities, direct observations, and scientific research training enhances students’ overall capabilities. This holistic approach not only builds a robust theoretical foundation but also sharpens their practical operation and problem-solving skills, significantly benefiting their future career development.

(7) Improve the construction of practical teaching resources

Practical teaching resources play a crucial role in cultivating application-oriented talents. In response to the rapid advancements in science and technology, as well as the dynamic changes within the industry, the development of practical teaching resources must align with current scientific progress and industrial transformations. This course establishes a comprehensive teaching resource database for Fluid Mechanics and Hydraulic Transmission, aligned with the course content.

This database is designed to facilitate students' engagement and enhance their learning experience outside of classroom hours.

(8) First principles teaching

Practical engineering problems are often derived from the first principles of related fields. These principles are emphasized in the newly revised engineering education certification standards. In response to changes in these certification standards, all departments and courses are exploring how to incorporate first principles into personnel training. The introduction of first principles undoubtedly sets higher standards and demands for the training of application-oriented talents. This focus on first principles is a key feature of the new version of the engineering education certification standards.

This course emphasizes a comprehensive understanding of the fundamental principles underlying the development of various phenomena to help students discover the most basic solutions. Fluid flow and energy flow run through the course of Fluid Mechanics and Hydraulic Transmission. Specifically, the course explores the foundational principles and issues in these fields from the perspective of pressure changes resulting from volume alterations. This approach aims to inspire learning interest and deepen students' grasp of the related concepts.

5. Conclusion

The engineering education accreditation standard serves as a crucial benchmark for assessing the quality of engineering education. It holds significant practical and theoretical relevance in enhancing learning quality, optimizing curriculum, and strengthening faculty development. Training under this standard is tailored to the specific orientation of the institution, addressing industry needs by establishing a robust curriculum system. This system effectively shortens the transition period for graduates from academia to industry, ensuring the development of outstanding talents who meet the demands of the engineering sector. Curriculum instruction, when guided by the engineering education accreditation standards, significantly enhances educational quality and international competitiveness. It fosters the integration of engineering education with practical application, promotes continuous improvement and innovation in teaching, and cultivates exceptional engineering talent for society. Ultimately, this contributes to the advancement and progress within the engineering field.

"Fluid Mechanics and Hydraulic Transmission" is a critical course for mechanical engineering majors. In light of the new demands imposed by engineering education accreditation on the course, this paper identifies existing shortcomings in the teaching of "Fluid Mechanics and Hydraulic Transmission" based on its instructional characteristics. Specifically, many local universities exhibit numerous deficiencies, such as a reliance on a singular teaching methodology, a significant lack of practical instruction, diminished student interest, and a disconnect between theoretical understanding and practical application. To address these issues and enhance the training quality of application-oriented personnel, this paper proposes corresponding guidance and implementation strategies. These include diversifying teaching methods, enhancing practical components, implementing the OBE philosophy, and bridging the gap between theory and practice. Such measures aim to better align the course with industry requirements and improve the preparedness of graduates entering the field.

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