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A Modular Teaching Model for Fluid Mechanics in Civil Engineering under the New Engineering Education Framework

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Abstract

Driven by national strategies such as innovation-driven development, building a strong transportation nation, and the Belt and Road Initiative, a new economic paradigm—defined by emerging industries, advanced technologies, and innovative models—is rapidly taking shape. In response, China has launched the New Engineering Education initiative as a strategic effort to lead higher education reform, address the challenges of the ongoing industrial revolution, and cultivate talent for emerging sectors. This educational approach emphasizes not only interdisciplinary integration and innovation but also the development of students' creative thinking, comprehensive competencies, and social responsibility. Its overarching goal is to nurture outstanding engineering professionals who are capable of interdisciplinary collaboration, equipped with entrepreneurial and innovative mindsets, and adaptable to the evolving demands of society. Using the Fluid Mechanics course in civil engineering as a case study, this paper examines current instructional challenges and explores the design and implementation of a modular teaching model within the framework of New Engineering Education. The aim is to enhance the quality of fluid mechanics instruction and offer insights for the development and reform of related engineering courses.

Keywords

Fluid Mechanics; New Engineering; Modular Teaching.

1. Introduction

The "new engineering" initiative has significantly raised the bar for talent development. Conventional engineering programs must now grasp its core mandate—new programs and new standards—and proactively reinvent themselves. Curricula should be purpose-built to supply talent for emerging industries and to nurture a new generation of civil engineers who can thrive in the context of "new infrastructure." In recent years, universities worldwide have embedded this ethos into program and course design. Professor Lin Jian of Tsinghua University's Institute of Education[1-2], for instance, argues that graduates should master seven key competencies, ranging from complex-problem solving and innovative thinking to teamwork and communication. Sichuan University has restructured its civil-engineering curriculum and content accordingly [3]; Hohai University has woven the new-engineering philosophy into the very fabric of its programs, piloting novel pedagogies that strengthen students' all-round capabilities [4]. Likewise, Wang Feng and co-workers [5] have trialed alternative instructional models that fuse theory with practice, boosting students' hands-on skills, cultivating self-directed learning, and markedly improving instructional quality.

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2. Problems in Fluid Mechanics Teaching

Compared with the requirements of new engineering construction, the Fluid Mechanics course has the following shortcomings:

(1) Course objectives do not match the requirements of new engineering construction. The civil engineering industry is facing opportunities and challenges for transformation and upgrading, new industry development needs, and fierce international competition. The current course objectives focus on cultivating basic problem-solving abilities, but there is still room for improvement in innovation ability and high-quality attainment.

(2) Course content lacks timeliness and interdisciplinary integration. With the rapid development of digitalization and intelligence, new technologies and industries continue to emerge, and the industry has put forward new requirements for civil engineering talents. However, the teaching content has not kept pace with the times, and interdisciplinary integration is insufficient, which does not match the talent needs of industrial upgrading.

(3) Practical teaching lags behind the needs of ability cultivation. The experimental teaching of this course is mainly verification-based experiments with limited class hours. The practical teaching mode is single, and modern teaching methods such as digital modeling and simulation technology are insufficiently applied, which cannot effectively stimulate students' creativity and initiative. There is a lack of deep integration among knowledge, practice, innovation, and ability cultivation, and it is impossible to effectively promote the transformation of knowledge into innovation ability.

Based on the above problems, the Fluid Mechanics course urgently needs to integrate the requirements of new engineering construction, reconstruct the course training objectives based on industrial development and social needs, innovate the teaching content, improve the teaching effectiveness, and cultivate high-quality composite new engineering talents with strong engineering core abilities, innovation abilities, and international competitiveness.

3. Exploration of Modular Teaching Mode for Fluid Mechanics under the Background of New Engineering

3.1. Course Organization and Design

(1) Strengthen interdisciplinary integration and implement modular teaching.

Strengthen interdisciplinary integration and increase questions and assignments related to course integration. Add interdisciplinary content with computer science, environmental engineering, shipbuilding, and other majors. For example, when integrating with environmental engineering, explain the laws of pollutant diffusion, migration, and transformation in water bodies, and how to use fluid mechanics principles to control water pollution. When integrating with the shipbuilding industry, introduce the history of Jiangxi's shipbuilding industry and analyze the motion response of ships in waves and the force on hull structures, so that students can understand the application of fluid mechanics in other fields.

(2) Innovation of teaching content and resource construction.

Fluid mechanics is widely used in many industrial sectors, such as aviation, shipbuilding, power, machinery, and metallurgy. With the development of technology and the needs of engineering practice, the teaching content should also regularly add cutting-edge research results in the field of fluid mechanics related to civil engineering, so that students can understand the latest developments in the discipline and broaden their international horizons.

Fully consider the actual situation of local education, transform high-quality teaching resources from abroad or other regions, absorb and learn from successful experiences in other regions through cooperation and exchanges, and promote the construction of this course. Introduce

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modern calculation methods, such as the finite difference method and finite element method, so that students can understand complex problems in fluid mechanics through computer simulation.

(3) Reshape course training objectives with new engineering and promote teachers' professional ability improvement.

Teachers are the foundation and source of education. The construction of this course fully integrates the requirements of new engineering construction and the current needs of civil engineering talent cultivation, improves teachers' practical and innovation abilities, updates their professional knowledge system, promotes the improvement of teachers' professional abilities, gradually transforms them into "dual-teacher" teachers, and improves teaching effectiveness.

3.2. Modular Construction of Course Experiment System

Experimental teaching is the main carrier for achieving the goals of new engineering talent cultivation, an important part of integrating theory with practice in the teaching process, and an important means of cultivating students' hands-on ability, problem-solving ability, and innovation ability.

The current Fluid Mechanics course has a total of 8 hours of experiments, consisting of 4 verification-based experiments. In practice, it is found that the existing experimental courses have problems such as short experimental hours, insufficient depth of experimental content, unclear system, and inability to reflect high-level characteristics, which cannot effectively broaden students' horizons, enhance their independent thinking and hands-on ability, and lack deep integration between ability cultivation and quality improvement, making it impossible to effectively promote the transformation of knowledge into ability and quality.

Without changing the existing experimental hours, the project proposes a student-centered approach, integrating multiple verification-based experiments, developing discipline-specific experiments and independent innovation experiments, as well as numerical simulation technology experiments, to form a multi-level and multi-channel fluid mechanics experimental course system that supports each other. Among them, numerical simulation technology experiments refer to online fluid mechanics experiments carried out through online mobile platforms, which belong to the course experiment module and are required to be completed gradually outside of class in the form of after-class tasks.

Through the modular construction of the above experimental course system, a multi-level and multi-channel fluid mechanics experimental teaching system that combines physical experiments, mobile platforms, and information technology will ultimately be realized.

3.3. "Two-Dimensional, Three-Stage" Course Assessment

The course increases complex situational case analysis and innovative problem discussion in the assessment content to better stimulate students' thinking ability. In terms of assessment form, it increases the proportion of practical operation assessment, introduces group project-based assessment, and establishes a dynamic process assessment mechanism to provide real-time feedback on students' learning progress and ability improvement, so as to promote students' all-round development and better adapt to the development needs of new engineering. This is summarized as the "two-dimensional, three-stage" assessment and evaluation model (see Table 1).

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Table 1. "Two-Dimensional, Three-Stage" Teaching Assessment and Evaluation Model

Assessment Form Stages	Formative Assessment 50%			Project-Driven Flipped Classroom	Final Exam
	Pre-class	In-class	Post-class		
Online	5%	10%	5%	5%	
Offline		10%	10%	5%	50%
Assessment **Content**	Video learning, group discussions, basic tests, virtual experiments, etc.	In-class exercises, Q&A, group tasks, student presentations, experiments, etc.	Homework, project reports, lab reports, group presentations, peer reviews, etc.	Knowledge, ability, and literacy evaluation (see Table 2)	

3.4. Implementation Effects

Taking the opportunity of new engineering construction, the civil engineering major of our university has carried out teaching reform and practical activities for the Fluid Mechanics course. Through student analysis and course construction, this teaching reform has built a more forward-looking, innovative, and adaptable course teaching model, achieving multi-faceted and far-reaching goals. After the reform, the course content is closely aligned with the needs of emerging industries and the forefront of technological development, cultivating students' solid professional knowledge and interdisciplinary literacy. It enhances students' practical and innovative abilities, allowing them to be fully trained in actual operations and solving complex problems. It improves the teaching level and professional literacy of the teaching team, stimulating students' potential with more advanced and effective teaching methods. It promotes the optimization and efficient utilization of teaching resources, creating a good teaching environment. It also promotes the updating of educational concepts, cultivating new engineering talents with international vision, social responsibility, and sustainable development concepts, thereby continuously providing high-quality and innovative professionals for the progress and development of China's engineering field.

4. Conclusion

This paper takes the Fluid Mechanics course in civil engineering as the research object and explores the application of modular teaching mode in course teaching under the background of new engineering construction. Practice has proved that this teaching mode cultivates students' awareness and ability of innovation and entrepreneurship through course teaching and practical teaching, laying a foundation for their future career development and social contribution. In future teaching reforms, it should be widely promoted and applied to improve the quality of talent cultivation in civil engineering and other majors.

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