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Teaching Reform of Hydraulic Course for Engineering Application Ability Cultivation

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Abstract: *Addressing the issue of insufficient engineering application capabilities in the teaching practice of the hydraulics course, this study systematically explores how to optimize theoretical teaching content and reform experimental teaching methods. Emphasizing the concept of "engineering application," the study promotes classroom case teaching, integrates design experiments, focuses on process assessment, and establishes a teaching model for cultivating engineering application-oriented talents. In hydraulics teaching, the focus is on enhancing practical engineering and application abilities, cultivating students' skills in hydraulic design calculations, and providing a reference for teaching mechanics courses with an engineering application background.*

Keywords: *Hydraulics; Engineering Application; Teaching Reform*

1. Introduction

The hydraulics course is a fundamental professional course for majors such as Water Supply and Drainage Science and Engineering, Civil Engineering, and related fields. The theoretical aspect of hydraulics examines the equilibrium (including relative equilibrium) of liquids, primarily water, and the mechanical motion laws governing water flow. The application includes open channel, pipeline, weir, and more [1-4]. The hydraulics course contains a large number of formula derivations, and in practical engineering applications, there are numerous empirical and semi-empirical formulas. For instance, the Chezy formula, proposed by the French engineer Chezy based on river and canal measurements, and the simple yet widely used Manning formula. Students generally find hydraulics challenging due to the numerous coefficients and formulas, complex concepts, abstract knowledge points, and potential for confusion.

Hydraulics is a relatively independent mechanics course. As it is based on practice, it serves as an efficient engineering discipline. Its primary aim is to cultivate students' fundamental skills and abilities in hydraulic calculations for designing water-retaining structures, water discharge structures, and water conveyance structures [5]. Students learn and master the basic principles of mass conservation, momentum conservation, and energy conservation, and apply these principles to analyze real-world hydraulic problems, developing their ability to solve engineering challenges. Hydraulics also serves as the foundation for hydraulic calculations in professional courses such as water supply network design, pump, and pump station design, emphasizing practical application while integrating theoretical and practical aspects.

For students in Water Supply and Drainage Science and Engineering, in particular, the hydraulics course is extensive in class hours and is recognized as one of the more challenging university courses to understand. Due to inadequate mastery of knowledge points [6-7], students may struggle to build mechanical models and conduct relevant hydraulic design calculations, despite learning about various water flow phenomena and calculating the interaction forces between water flow and boundaries in water conveyance pipelines and channels.

Additionally, with the development of Computational Fluid Dynamics (CFD) and computer technology, complex flow fields that could not be directly observed before can now be analyzed through numerical simulations. However, current hydraulics courses rarely introduce the application of CFD, and the teaching content still primarily relies on traditional calculation methods and experimental demonstrations.

According to the undergraduate teaching philosophy of Wuhan Polytechnic University, which focuses

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on cultivating applied innovative talents and improving the quality of talent training, undergraduate education needs to cultivate comprehensive talents with both scientific knowledge and practical abilities. Based on this, the implementation of "quality-oriented education" and the significant research significance of the teaching reform of the "Hydraulics" course to enhance engineering application capabilities are emphasized [8-9].

2. Teaching Reform Goals

Emphasize the combination of theory and practice, continuous improvement, and teaching according to students' abilities. Implement the reform of the hydraulics course and experimental teaching to cultivate applied innovative talents. Strengthen training characteristics to develop applied innovative talents with strong engineering application capabilities, guiding students to become scientifically-minded, independent thinkers with innovative and practical abilities.

Based on professional characteristics and the features of professional course groups, explore and organize other theoretically strong mechanics courses with a good engineering application background through the teaching reform of the hydraulics course. Focus on enhancing students' practical abilities, problem-solving skills, and application abilities.

3. Teaching Reform Methods

3.1. Classroom Teaching

Starting from the introductory lesson, various examples are employed, such as the ancient Chinese measuring instrument—the copper pot dripper—which calculates time using the change in water level from a dripping copper pot. Students first learn about hydraulic structures such as cofferdams, open channels, and pipelines, analyze hydraulic problems encountered in engineering examples like centrifugal pumps and siphon tubes, and compare these with upcoming course topics like the differences and essence of fire hose nozzles and artificial rainfall nozzles. Applications of hydraulic principles in common engineering practices, such as Pitot tubes and Venturi meters, are listed to create teaching scenarios before introducing the teaching content, learning methods, and development history. From the first lesson, the application of hydraulics in daily life is introduced to guide students in understanding the theoretical and practical aspects of the hydraulics course, ensuring that "engineering application" permeates the entire course. Historical water management figures and stories, biographies of Bernoulli, Reynolds, Blasius, and Nikuradse, and water history education are introduced to inspire students' interest in hydraulics. Students also learn about famous historical water projects like Dujiangyan and Lingqu, as well as modern water projects such as the South-to-North Water Diversion Project and the Three Gorges Dam, fostering national pride, social responsibility, and a pioneering spirit.

3.1.1. Modular Teaching

Based on fundamental theories and engineering applications, the hydraulics teaching content is divided into fundamental and application-focused modules. The fundamental module emphasizes mastering theoretical knowledge, ensuring sufficient teaching hours for the continuity equation, energy equation, and momentum equation. The engineering application module is reorganized according to the requirements of different majors, such as civil engineering focusing on applications in hydraulic engineering, and water supply and drainage engineering focusing on applications in water supply, drainage, and environmental engineering. This module is adjusted to meet teaching requirements, with mandatory and optional topics appropriately designated. College students who intend to enroll in graduate programs are encouraged to enhance their skills. Engineering cases are introduced alongside theoretical and practical teaching to broaden students' knowledge systems, emphasizing the integration of fundamental and engineering sciences.

3.1.2. Course Resource Integration

Utilizing existing textbooks and reference materials in hydraulics, high-quality open course resources are shared to develop excellent online and offline courses. These resources include course introductions, implementation plans, teaching calendars, syllabus, courseware, teaching videos, virtual simulation experiment systems, question banks, engineering cases, chapter quizzes, and more. Traditional classroom teaching is the mainstay, with online classrooms as a supplement, fully leveraging the importance of online resources to achieve complementary teaching. A smart classroom is established for autonomous

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learning, promoting the new form of "Internet + Higher Education." By integrating quality resources such as MOOC and micro-courses, the teaching content becomes more diverse and richer, facilitating easier learning for students. For interested and capable students, hydraulic numerical simulation software like ANSYS Fluent and COMSOL Multiphysics is introduced to simulate various flow conditions, providing opportunities for students to explore new methods and models for solving engineering problems.

3.1.3. Emphasis on Classroom Discussion

Discussion sessions are scheduled for key chapters, requiring students to prepare in advance and engage in effective classroom interactions on the research background and hydraulic challenges of engineering cases, such as whether to use hydraulically optimal or economically practical cross-sections in open channel design. Design problems guide cooperative discussions to enhance classroom activity, with teachers actively facilitating and strengthening teacher-student interaction to increase students' interest in learning. Engineering applications assist teaching, with students identifying the applications of orifice and nozzle flows in water supply and drainage engineering. Orifice flow is commonly used in sedimentation tanks and filters for water treatment, while nozzle flow is used in aeration tank drainage pipes for sewage treatment. Discussions on why the flow of a cylindrical external nozzle is greater than that of an orifice are introduced. Teachers should encourage unique insights and advocate for an exploratory spirit, cultivating students' innovation and expressive abilities.

3.1.4. Integration of Case Teaching

Engineering cases are incorporated into course teaching to bridge the gap between theoretical content and engineering applications. Before explaining theoretical knowledge, problems in engineering cases are analyzed. For example, in the chapter on head loss, a case study on calculating the lift of a long-distance water pump is developed based on actual engineering conditions. Students independently propose factors to consider in the lift design calculation, such as frictional head loss and local head loss along the suction and discharge pipes, and the most unfavorable point, combining relevant professional knowledge to analyze the problems and reasons. The importance of head loss is clarified, linking engineering problems with theoretical knowledge to deepen students' understanding and mastery of the concepts learned in engineering case studies while improving their ability to analyze engineering practice problems. Connecting theoretical abstractions with practical engineering realities, such as linking the hazards of water hammers in pressurized pipelines with the choice of installing water hammer eliminators by water companies and municipal departments, helps students understand the need to eliminate destructive shock waves to protect pipelines. Strengthening the engineering background introduction of textbook examples and post-class exercises, case teaching can be combined with graduation design, differing from textbook examples by including simplified graduation design calculation examples from related majors. Combined with engineering overviews and design requirements, knowledge units are decomposed, guiding students to actively think, determine relevant parameters, and comprehensively understand and master the knowledge points learned. This stimulates students' enthusiasm and initiative and cultivates their ability to solve actual engineering problems.

3.2. Practical Teaching

Due to increased requirements for students' practical abilities, the duration of hydraulics experiments has been extended from 8 to 16 hours, introducing pre-experiment, mid-experiment, and post-experiment learning phases to form a complete learning loop integrating experimental teaching with classroom instruction, preview, and review. Fully utilizing online experimental resources, hydraulic experiment teaching simulation software is introduced for preparatory purposes. By simulating the experimental process online beforehand, students can better understand theoretical knowledge, operate the water pump to regulate the flow, perform venting and pressure measurements, and more, thereby allowing them to intuitively grasp the experimental process, principles, equipment structure, and observe fluid flow in pipelines. Students can also observe and record experimental data in simulation software, analyze the relationship between flow rate and pressure difference, and flexibly adjust experimental parameters as needed to explore fluid dynamics under different conditions.

Simultaneously, diverse experimental projects are systematically arranged according to syllabus requirements. The original experimental teaching content, primarily consisting of verification experiments [10], is supplemented with open and innovative design experiments aimed at solving real-world problems. For instance, in the Venturi experiment, besides the conventional measurement and calibration of the Venturi pipe's flow coefficient, a design experiment is added. This design experiment

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requires students to create an experimental plan based on theoretical analysis, measure relevant parameters, and determine the maximum effective head and maximum allowable flow of the Venturi pipe under maximum vacuum conditions. Emphasizing the exploratory, practical, and comprehensive nature of professional experimental teaching, multi-level experiments, including demonstration experiments, verification experiments, comprehensive experiments, and design experiments, are conducted to provide a platform for the innovative and personalized development of students, thereby achieving the goal of cultivating students' engineering practice abilities.

3.3. Reform Examination Methods

Process assessment is emphasized, acknowledging that the cultivation of knowledge and abilities cannot be achieved through cramming. Combining process assessment with result assessment by incorporating checkpoint quizzes, midterm exams, and other multi-evaluation systems focuses on the accumulation and integration of knowledge over time. This shift from "teaching knowledge" to "teaching ability" enhances engineering students' capacity to apply theoretical knowledge to engineering practice. The exam content should balance subjective and objective questions, with an appropriate increase in comprehensive and application-oriented subjective questions. The final exam is recommended to be semi-open book, enhancing students' ability to analyze and solve problems while avoiding rote memorization. Experiment assessment includes basic experimental theory, observation and operation skills, and innovative ability. Extra points can be awarded if students improve experimental apparatus and optimize experimental processes.

Through the reform of the hydraulics course teaching as shown in Figure 1, students should master the basic concepts, principles, and skills of hydraulics. This reform strengthens their independent thinking, comprehensive analysis, and practical application abilities, aiming to improve teaching quality and the effectiveness of teaching reform.

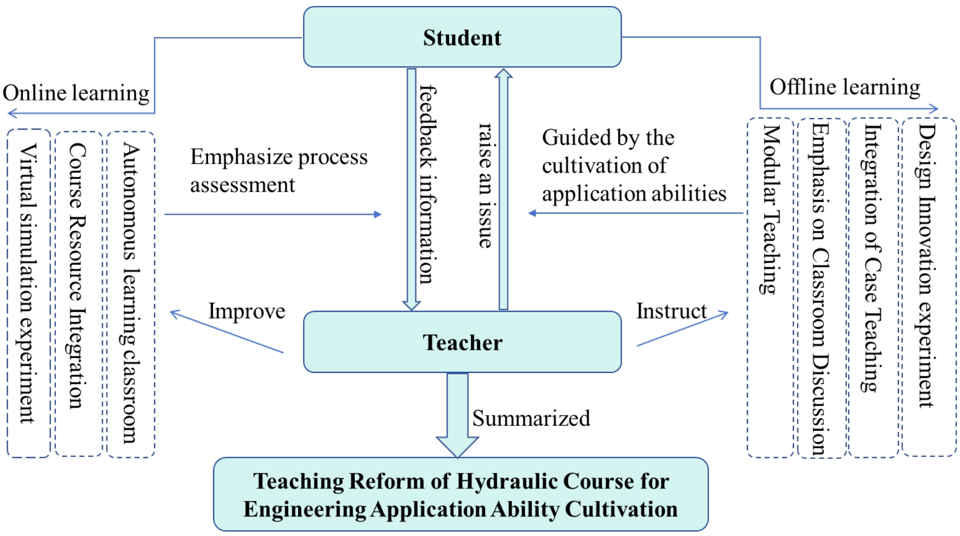

Figure 1: Framework of Hydraulic Teaching Mode.

4. Conclusions

1) Integrating the characteristics of the hydraulics course with the objectives of teaching reform, the teaching content is optimized through a student-centered approach, and experimental teaching methods are reformed to emphasize the engineering practicality of the hydraulics course. This aims to develop students' basic skills in hydraulic design calculations for water-retaining, water conveyance, and water discharge structures, thereby equipping them with practical application abilities for problem-solving.

2) The experimental component is essential for cultivating students' innovative abilities and engineering practice skills. Through multi-level experiments, including demonstration, verification, comprehensive, and design experiments, a platform is provided for the innovative and personalized development of students, thereby achieving the goal of cultivating their engineering practice abilities.

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References

[1] Zurong Ding. Fluid mechanics: an upper volume [M]. Beijing: Higher Education Press, 2013.
[2] Wu Wei, Zhang Weijia. Hydraulics [M]. Beijing: China Construction Industry Press, 2020.
[3] Mo Nairong. Engineering Fluid Mechanics [M]. Wuhan: Huazhong University of Science and Technology Press, 2015.
[4] Zhao Zhenxing, He Jianjing. Hydraulics [M]. Beijing: Tsinghua University Press, 2016.
[5] Wang Lijun. Practice and discussion on teaching reform of Hydraulics course[J]. China Science and Education Innovation Guide, 2012, (04): 74.
[6] Meng Xianmeng. Discussion on the teaching experience and teaching reform program of the course "Hydraulics"[J]. China Geology Education, 2011, 20 (04): 93-95.
[7] Yang Haohan, Zhu Yongheng, Cong Haibing. Exploration of the Reform of the Course System of "Hydraulics" in Water Supply and Drainage Science and Engineering [J] Science and Education Guide, 2024, (13): 48-50.
[8] WU Lei, LU Hongxing, MA Xiaoyi. Research on the new teaching mode of "hydraulics" aiming at the cultivation of high-quality engineering talents[J]. Heilongjiang Education (Higher Education Research and Evaluation), 2017, (12): 75-77.
[9] Wang Ye, Sun Sanxiang. Research on a new teaching model for fluid mechanics that highlights practical aspects [J]. Journal of Lanzhou Jiaotong University, 2014, 33 (02): 162-165.
[10] Gao Shuhui, Chai Xiaojun, Hu Guanglu. Pilot study on student-centered teaching and evaluation of hydraulic experimental courses [J]. Science and Education Guide, 2023, (32): 123-125.