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Reform and Practice of Hydraulic Structures under the Background of New Engineering

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Abstract

The course of Hydraulic Structures is the core and backbone course of water conservancy and hydropower engineering, playing a leading and exemplary role in professional construction. In the context of the new engineering discipline, traditional teaching faces problems such as a lack of systematic optimization of curriculum system and teaching requirements, inability to reflect the latest technology in textbook content, single teaching method, and disconnection between theoretical teaching and engineering practice. This article proposes measures such as restructuring course content, reforming teaching methods to stimulate students' subjective initiative, strengthen their practical abilities, improve their professional literacy, and cultivate their ability to solve complex engineering problems and innovate.

Keywords

New Engineering; Hydraulic structures; Content reconstruction; Teaching method.

1. Introduction

Since February 2017, when the Ministry of Education initiated the new engineering education initiative, particularly in the "Tianjin University Action Plan" which explicitly stated: "Align with industrial demands to establish new majors and construct a new framework for engineering disciplines; adapt to technological advancements to update content and modernize the knowledge system for engineering professionals." [1-2]. According to the basic requirements of the construction of new engineering disciplines, it is particularly important to reform the training system of water conservancy and hydropower majors, innovate the teaching mode of the course Hydraulic Structures, and cultivate composite talents in water conservancy engineering.

The course of Hydraulic Structures is the core course of the Water Resources and Hydropower Engineering major, playing a leading and exemplary role in the construction of the profession. It can be said that the construction level of the course Hydraulic Structures represents the construction level of the water conservancy and hydropower engineering profession.

2. Problems in the Teaching of Hydraulic Structures Course under the Background of New Engineering

At present, there are still the following problems in the construction of applied undergraduate education courses for "Hydraulic Structures" under the background of new engineering disciplines [3-6]: (1) there are contradictions between course content and class hours, the course system and teaching requirements lack systematic optimization, and the textbook content cannot reflect the latest technology; (2) Most teachers focus on lecturing, with

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relatively single teaching methods. Students passively receive theoretical knowledge, resulting in unsatisfactory teaching outcomes; (3) Students find it difficult to use their theoretical knowledge to solve problems encountered in engineering practice, and there is a disconnect between theoretical teaching and engineering practice.

This project will conduct reform research in two aspects: reconstructing course content, reforming teaching methods in the teaching process of Hydraulic Structures. It aims to unleash students' subjective initiative, strengthen their practical abilities, and enhance their professional competence.

3. Reform and Practice of Hydraulic Structures under the Background of New Engineering

3.1. Research on the Content Reconstruction of the Course Hydraulic Structures under the Background of New Engineering

In recent years, with the advancement of teaching reform, the class hours of professional core courses have also been compressed. At present, the teaching hours for "Hydraulic Structures" in water conservancy and hydropower engineering at Yaohu College of our university are 64 hours, which is relatively scarce. At the same time, the concept of hydraulic design is constantly updated, and the content of textbooks is constantly increasing. The textbook "Hydraulic Structures" (National Planning Textbook for the 15th Five Year Plan) (edited by Lin Jiyong, 6th edition) has reached 583 pages. How to enable students to master the traditional design theory of hydraulic structures and understand the design concepts under the background of new engineering in a limited time is a difficult problem.

Under the background of emerging engineering education, aiming at the problems of the contradiction between curriculum content and class hours, the lack of systematic optimization of curriculum system and teaching requirements, and the failure of textbook content to reflect the latest technologies in the current Hydraulic Structures curriculum content, this research reconstructs the curriculum content by analyzing the characteristics of its curriculum system.

(1) Co-teaching Plan for Hydraulic Structures and Introduction to Water Conservancy Engineering

To address the contradiction between curriculum content and class hours, this research proposes a co-teaching plan for Hydraulic Structures and Introduction to Water Conservancy Engineering. As an introductory course for the Water Conservancy and Hydropower Engineering major, Introduction to Water Conservancy Engineering is taught in the first semester of the freshman year in our university. Its teaching objectives include mastering the functions, structures and working principles of hydraulic structures and hydropower station equipment, understanding the construction and development of the water conservancy and hydropower industry under the new situation; mastering the basic theories and methods of water conservancy engineering design, construction and operation, and understanding the concepts and basic methods of water conservancy engineering safety monitoring. Therefore, the easy-to-understand content in Hydraulic Structures such as the definition, classification, working principles, advantages and disadvantages of various hydraulic structures can be emphasized in Introduction to Water Conservancy Engineering. Removing the overview of hydraulic structures can alleviate the shortage of class hours for Hydraulic Structures to a certain extent, allowing more time for detailed explanation of relevant knowledge points. On this basis, students can also connect the corresponding engineering background when learning other prerequisite professional courses, increasing their learning interest.

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(2) Co-teaching Plan for Hydraulic Structures and Prerequisite Professional Courses

To solve the problem of the lack of systematic optimization of the curriculum system and teaching requirements, a co-teaching plan for Hydraulic Structures and prerequisite professional courses is proposed[7]. Hydraulic Structures has many prerequisite professional courses with scattered knowledge. Therefore, the curriculum system can be optimized as a whole, and analysis can be carried out in combination with actual hydraulic structures in the teaching of prerequisite courses. For example, in the Mechanics of Materials course, the mechanical method of materials for gravity dam stress analysis can be taught; in the Structural Mechanics course, the pure arch method for arch dam stress analysis can be taught; in the Hydraulics course, the hydrostatic pressure in gravity dam load calculation and seepage analysis of earth-rock dams can be taught; in the Soil Mechanics course, the slope stability analysis of earth-rock dams can be taught. In prerequisite courses, due to students' lack of relevant basic knowledge, the content teaching should be simplified in combination with the learned knowledge, and problems irrelevant to the prerequisite course should be given as known conditions. Combining theory with practice can not only cultivate students' engineering thinking ability and improve their learning enthusiasm, but also make it easier for students to understand and digest the content when learning Hydraulic Structures, thus saving some class hours.

(3) Collaborative Introduction Plan of the Four New Technologies under the Background of Emerging Engineering Education

To tackle the problem of textbook content failing to reflect the latest technologies, a collaborative introduction plan of the four new technologies (new theories, new methods, new materials and new processes) under the background of emerging engineering education is proposed. With the continuous development of science and technology, the four new technologies are constantly applied in actual engineering, but there is a lag in textbook content. Therefore, teachers should constantly study the most cutting-edge monographs and papers in the industry and teach students the latest theories, methods, materials and processes. Teachers should guide students to understand the most advanced technical level, development status and research directions in the field of water conservancy and hydropower engineering, enabling students to continue exploration and innovation on the basis of previous research. The four new technologies to be supplemented and taught in this course are shown in Table 1.

Table 1. The Four New Technologies to be Supplemented and Taught in This Course

Type of the Four New Technologies	Content of the Four New Technologies
New Theories	BIM design, digital twin technology
New Methods	Finite element method, back analysis method
New Materials	Cemented sand and gravel, rock-filled concrete
New Processes	Overflow earth-rock dam, hydraulic lifting dam

3.2. Research on the Reform of Hydraulic Structures Teaching Methods under the Background of New Engineering

Teaching methods are important factors affecting learning interest and determining teaching quality. In recent years, online teaching modes such as Xuexitong and MOOCs have been applied in the teaching of Hydraulic Structures in our university. However, due to the strong theoretical, practical and comprehensive nature of the course, most teachers still adopt the typical teacher-led teaching mode, i.e., lectures combined with multimedia courseware, with relatively single teaching methods. Students lack practical training, resulting in unsatisfactory teaching effects.

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Under the background of emerging engineering education, aiming at the problems of teachers' preference for traditional teaching and students' lack of practical training in the current teaching of Hydraulic Structures, this research carries out reform studies on the teaching methods from the following aspects.

(1) Stimulating Interest with Major National Strategic Projects

"Interest is the best teacher" reveals the true meaning of learning. When explaining the introduction, first introduce the policies and guidelines on water conservancy in the Central Government Document No.1 in the past five years to make students understand the strategic height of water conservancy and enhance their sense of pride and mission as water conservancy professionals; then, introduce the national water conservancy situation and the major water conservancy projects constructed in Jiangxi Province in the past ten years with pictures and videos, enabling students to see the good employment prospects in the future, enhance their professional confidence and better engage in the course learning. Meanwhile, when explaining each type of hydraulic structure, first introduce a typical major national strategic project, and explain the application and precautions of specific knowledge points in combination with the project to stimulate students' interest. The major national strategic projects introduced for different hydraulic structures are shown in Table 2.

Table 2. Major National Strategic Projects Introduced for Different Hydraulic Structures

Type of Structure	Major National Strategic Project	Notes
Gravity Dam	Three Gorges Gravity Dam	The world's largest water conservancy pivot project
Arch Dam	Xiluodu Arch Dam	China's second largest hydropower station
Earth-rock Dam	Xiaolangdi Earth-rock Dam	A key project for the harnessing and development of the Yellow River
Sluice	Gezhouba Spillway Sluice	The first large-scale water conservancy project on the Yangtze River

(2) Interactive Classroom Questioning and Doubting

At the beginning of each class, first review the main content of the previous class and put forward the connection between the current class and the previous class or prerequisite professional courses. Aiming at the key and difficult points of the current class, ask students to answer questions to stimulate their ability to analyze problems; or encourage students to raise questions to stimulate their ability to think about problems. In this way, students can keep up with the teacher's teaching progress at all times, be ready to answer or raise questions at any time, develop good classroom habits, realize the communication and interaction between teachers and students, and improve teaching effects.

(3) Combination of Self-study and Lecture

The teaching method combining self-study and lecture can be adopted for class hours with similar teaching content. For example, when teaching the section of sluice chamber stability analysis, assign thinking questions in advance and arrange students to study independently before class. The thinking questions include: What is the checking object of sluice chamber stability analysis? What are the loads acting on the sluice chamber and how to combine them? What are the analysis methods for the anti-sliding stability of the sluice chamber along the sluice base and their applicable conditions? Students are prompted to learn by referring to the relevant knowledge of gravity dam anti-sliding stability analysis. In class, the effect of self-study is tested by classroom questioning. In this way, there is no need for detailed explanation of this part of the content in class, but a centralized explanation of students' difficult points in the form

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of Q&A. Since the content taught after self-study is the common difficult points for students, they will listen more carefully.

(4) Curriculum Discussion on Hot Issues

As an efficient way of learning and communication, hot issue discussion has been widely used in the education field. Aiming at some current hot issues related to this course, teachers provide students with relevant materials before class to help them understand and familiarize themselves with the hot issues. Students are encouraged to make full use of network resources, independently consult relevant literatures, study them carefully, form personal cognition and actively express personal opinions. This process is conducive to students' active thinking and purposeful learning, and stimulates their learning interest and innovative ability. The hot issues to be supplemented and taught in this course are shown in Table 3.

Table 3. Hot Issues to be Supplemented and Taught in This Course

Type of Structure	Hot Issues
Gravity Dam	Aquatic ecological problems of the Three Gorges Dam
Arch Dam	Seismic safety of ultra-high arch dams
Earth-rock Dam	Dam type selection for 400-meter-level ultra-high dams
Sluice	Poyang Lake Water Conservancy Pivot Project

(5) Detailed Analysis of Typical Cases

In accordance with the requirements for the design ability of hydraulic structures, a teaching mode integrating "teaching, learning and doing" with projects as carriers is implemented. In the specific teaching process, a representative, typical and complete real engineering project in Jiangxi Province is selected as the carrier for gravity dams, arch dams, earth-rock dams and sluices and integrated into the curriculum content. Combined with typical projects, the basic theories of hydraulic structures are explained, and the problems in the design, construction or operation of hydraulic structures are analyzed, integrating theory with practice. The typical cases in Jiangxi Province to be taught in this course are shown in Table 4.

Table 4. Typical Cases in Jiangxi Province to be Taught in This Course

Type of Structure	Typical Case	Notes
Gravity Dam	Jingshan Rock-filled Concrete Gravity Dam in Dongxiang County	The first rock-filled concrete gravity dam in Jiangxi Province
Arch Dam	Shankouyan Roller Compacted Concrete Arch Dam in Luxi County	The first roller compacted concrete arch dam in Jiangxi Province
Earth-rock Dam	Zhelin Clay Core Earth-rock Dam in Yongxiu County	The largest earth dam reservoir in Asia
Sluice	Xiajiang Water Conservancy Pivot Project in Xiajiang County	A regulatory water conservancy pivot project on the Ganjiang River

(6) Expert Lectures Guiding Exploration

The fundamental way to cultivate applied undergraduate talents is the in-depth integration of universities and enterprises. Combined with the current water conservancy development situation, chief engineers, project person in charge and front-line technical personnel from provincial enterprises with rich practical experience such as Jiangxi Academy of Water Conservancy Sciences (research institution), China Railway Water Conservancy and Hydropower Planning and Design Group Co., Ltd. (design institution) and the Second Engineering Bureau of China Anneng Group Co., Ltd. (construction institution) are invited to

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give special lectures to students after class, giving full play to the solid professional and technical capabilities of enterprise experts.

(7) Program Teaching to Improve Interest

Some contents of hydraulic structures involve a huge amount of calculation, which is almost impossible to complete by manual calculation. For example, the calculation of arch dam body stress, even with the simplest arch crown beam method, takes a very long time and is prone to errors if calculated manually, while it can be completed in a few seconds with the help of programs. Teaching some mature and widely used calculation programs can lay a good foundation for students to work in design institutions. The calculation programs to be taught in this research are shown in Table 5.

Table 5. Calculation Programs to be Taught in This Research

Type of Structure	Program Name
Gravity Dam	Calculation program for anti-sliding stability and dam body stress of gravity dams
Arch Dam	Calculation program for arch dam body stress by arch crown beam method
Earth-rock Dam	Calculation program for seepage and slope stability of earth-rock dams
Sluice	Calculation program for sluice chamber stability and sluice floor structure

4. Conclusions

Students cultivated under the construction and development of emerging engineering education should have high practical and innovative abilities. Aiming at the problems of traditional teaching such as textbook content failing to reflect the latest technolo gies, students' difficulty in applying learned theoretical knowledge to solve engineering practice problems, and the disconnection between theoretical teaching and engineering practice, measures such as reconstructing curriculum content, reforming teaching methods are proposed. The teaching reform can further adapt to the new development needs of the water conservancy engineering industry and cultivate a group of innovative engineering talents with scientific thinking and the ability to solve complex engineering problems in the field of water conservancy engineering and related fields.

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