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Original Paper

Exploration of Teaching Reform in the Course of Concrete Structure Design Principles in the Context of the New Era

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Abstract

In response to the requirements for cultivating applied talents in civil engineering under the background of the new era, and addressing the practical problems existing in the teaching of the course on concrete structure design principles in higher education institutions, this paper conducts an analysis of the current situation and challenges of the course teaching. It focuses on issues such as the abstract difficulty of teaching content, the singularity of teaching methods, and the lack of practical teaching. Combining the characteristics of the course and the industry's demand for talent capabilities, the paper explores and outlines reform measures, including optimizing course content, transforming the roles of teachers and students, and integrating theory with practice. The aim is to provide insights and inspiration for the teaching of related courses.

Keywords

Concrete Structure Design Principles, Teaching Reform, Applied Talents, Integration of Theory and Practice

1. Introduction

Since the beginning of the 21st century, digital technology has rapidly developed and become widespread in various fields, leading to significant changes in people's ways of life and roles in society. Emerging technologies such as big data, the Internet of Things (IoT), artificial intelligence, and 5G have prompted the education sector to consider the competencies and qualities future society requires from its workforce. The 19th National Congress of the Communist Party of China emphasized the need to "build a large army of knowledgeable, skilled, and innovative workers, promote the spirit of model

workers and craftsmanship, and create a social atmosphere of honoring labor and the dedicated pursuit of excellence." With continuous societal development and progress, the practical nature of civil engineering practices necessitates a higher education that goes beyond theoretical teachings. It should emphasize the integration of theory with engineering practice to cultivate the ability of university students to solve real-world problems, enabling them to adapt to the complexities of construction sites.

Transforming education and empowering the enhancement of teaching quality require a shift in mindset, exploration of new organizational methods for teaching and learning, and making competency development the core focus, thus constructing an ecologically sound educational application and practice.

The course on the principles of concrete structure design is not only a fundamental subject in the field of civil engineering but also a core course in our school, serving as a compulsory course for civil engineering students. This course is crucial as it bridges prior knowledge, including the study of building materials, theoretical mechanics, material mechanics, and structural mechanics, with subsequent specialized courses in civil engineering, urban underground space engineering, bridge and river-crossing engineering, among others. The course encompasses both theoretical knowledge and practical elements such as formula derivation, course design, and experimental teaching. Moreover, it addresses relevant industry standards in civil engineering. Therefore, using this course as a platform for teaching reform exploration holds significant implications.

2. Current Research Status and Significance of Teaching on the Principles of Concrete Structure Design

2.1 Current Research Status

Kuang Yachuan proposed several suggestions for the teaching process of the principles of concrete structure design. Firstly, he recommended the use of multimedia teaching methods, such as incorporating experiment videos with hyperlinks, to transform the dull textual teaching into vivid multimedia cases, thereby enhancing teaching quality. Secondly, he emphasized linking concrete structure knowledge with the needs of human society to stimulate students' learning interest. Thirdly, he advocated keeping abreast of and introducing the latest developments in the field, broadening students' horizons, and fostering their interest in research. Lastly, he encouraged using questioning techniques in class to bring out key points, promoting mutual communication and self-study among students, and fully mobilizing students' initiative.

Wang Fang and others, by summarizing the deficiencies in the teaching of the "Principles of Concrete Structure Design" course at their school and considering the characteristics of applied schools, proposed teaching reform measures based on the cultivation of applied talents. They used typical examples to inspire students' learning interest, explained knowledge points in connection with industry standards, and allowed students to understand and master the entire process of component design and calculation through course design.

Cheng Yi suggested several reforms for the course on the principles of concrete structure design. These include using practical case analysis as a model to consolidate students' basic skills and methods in component design, adopting a flipped classroom to achieve a student-centered learning mode, collaborating with enterprises to jointly formulate teaching content and implementing a blended learning mode through Building Information Modeling (BIM) for visualized simulation teaching.

Qin Shiqiang and others, taking the course design of concrete structure design principles as an example, reformed the teaching mode of the applied course, focusing on cultivating students' ability to solve practical complex engineering problems. Their reforms included organizing course design topics in small groups to promote independent thinking and discussions, precise task division for timely and quality completion, peer evaluation to enhance students' understanding of the entire calculation process, and defense to assess students' understanding of the course design content.

Literature research indicates that there is relatively extensive research on teaching reforms in traditional engineering courses, such as concrete structure design principles and engineering structure design principles, at various universities. However, the challenges lie in the theoretical nature and computational complexity of these courses, coupled with limited class hours and scarce time for practical experiments. Additionally, the difficulty of implementing teaching reforms stems from not aligning the reformative teaching models with the characteristics and operability of the courses. Therefore, the exploration of teaching reforms for the principles of concrete structure design remains necessary.

2.2 Significance of the Research

Among the more than three thousand universities nationwide, specialized courses and faculty constitute a significant portion. University students primarily engage in the study of specialized courses, while other general courses only occupy a small fraction of their time. The teaching of specialized courses is a core aspect of cultivating university students. Utilizing core courses to transform students' theoretical understanding into practical thinking, fostering their ability to solve complex engineering problems using learned knowledge, and inspiring innovative thinking is crucial. The continuous exploration and practice of how teaching reforms in specialized courses can enhance students' problem-solving abilities require the continuous efforts of specialized course teachers.

The course on the principles of concrete structure design involves a multitude of knowledge points, covering a series of foundational subjects such as advanced mathematics, physics, and mechanics. The numerous and complex formulas, coupled with limited practical applications, make the content abstract and create a lack of enthusiasm among students, leading to a significant fear of difficulty.

In the course of teaching, instructors need to carefully design their teaching methods, make full use of information technology to enrich teaching content, update teaching models, and not only make the classroom atmosphere lively and interesting but also increase students' interest in learning, making it easier for them to grasp key knowledge points.

3. Current Status and Challenges in the Teaching of Concrete Structure Design Principles

3.1 Abstract and Difficult-to-Understand Teaching Content

The content of the course, including concepts, formulas, parameters, construction requirements, and design specifications, is extensive. The course focuses on fundamental concepts, reinforcing basic theoretical knowledge, emphasizing the basic performance of structural components and design principles. However, the abundant and dry nature of the content poses challenges. Given the diverse levels of students' foundational knowledge and the multitude of professional basics covered in the course, maintaining a consistent teaching pace is challenging. This leads to polarized learning situations among students, resulting in a dilemma where some find the course difficult to learn, and instructors find it challenging to teach. To cope with the complex teaching tasks, there is a tendency to rush through the curriculum, leading to a passive teaching style that significantly diminishes students' interest in active learning, ultimately reducing their understanding and mastery of key concepts.

3.2 Limited Teaching Methods

Although multimedia teaching methods are now widely adopted in higher education, the course, which involves a significant amount of calculations, primarily relies on traditional chalkboard teaching supplemented by multimedia. This traditional teaching mode tends to be rigid, with students mostly passively receiving information. It lacks opportunities for students to express their understanding, ask questions, and engage in problem-solving, resulting in low learning efficiency. This monotonous teaching method makes it challenging for students to stay focused during lectures, and the lack of interaction between teachers and students fails to stimulate students' initiative and enthusiasm for learning.

3.3 Difficulty in Integrating Theory and Practice

While concrete structure design principles are fundamentally theoretical, the course requires an understanding of the entire process of reinforced concrete beam failure, reinforcement ratio and selection, control of concrete cracks, and the production of prestressed concrete components. These aspects necessitate timely integration with on-site construction processes for effective learning. However, the teaching process often neglects the integration of theory and practice. As a result, students' understanding remains superficial, and their ability to solve practical engineering problems is weakened. The failure to connect theoretical concepts with real-world construction scenarios hinders the development of strong problem-solving skills among students.

4. Teaching Reform and Exploration of Concrete Structure Design Principles

4.1 Optimization of Course Content

Given the challenges identified in the teaching of the "Principles of Concrete Structure Design," it is essential to scientifically structure the classroom content to shorten conceptual understanding time, promote thinking through practice, optimize teaching methods to stimulate student learning enthusiasm, and thereby cultivate students' comprehensive qualities and practical skills. The following reforms will

be implemented:

4.1.1 Theoretical Foundation Module

This module aims to impart the reliability concept of concrete structure design, limit state equations, and the ultimate limit states and serviceability limit states. Starting with the physical and mechanical properties of concrete and reinforcement, students will understand the characteristics of structural materials, laying a solid foundation for subsequent load-bearing calculations. This module adopts a blended learning approach, combining online and offline methods. Students are encouraged to engage in pre-class preparation, in-class reflection, and post-class review. Pre-class materials, such as videos, texts, or images, will be shared on the "Chaoxing Learning Platform" for self-paced online learning. In-class activities will include posing questions to guide active student thinking. Visual aids like images and videos will be used to explain fundamental concepts and theories. Homework will be assigned on the "Chaoxing Learning Platform" to reinforce post-class review.

4.1.2 Load-Bearing Capacity Calculation Module

This module covers major force systems, such as bending, compression, tension, and torsion. Students will calculate the load-bearing capacity of reinforced concrete components under these forces, understanding the failure states of concrete structures and the distribution of section stresses in various stages. Mastery of calculation formulas, symbols, coefficients, and assumed conditions is crucial. To enhance engagement, practice problems will be assigned for post-class exercises. Students will present their solutions in class, fostering mutual evaluation and deepening their understanding of relevant knowledge points.

4.2 Adoption of the "Identity Shift" Teaching Model

The traditional one-size-fits-all teaching model is no longer sufficient for evolving needs. Passive learning methods are outdated. The course will adopt a student-centered approach, transforming the traditional closed-classroom model into a new open-classroom model, allowing students to enjoy learning, become capable learners, and master the content.

Interesting nuggets of knowledge related to the application and development of reinforced concrete structures domestically and internationally, factors influencing concrete shrinkage and deformation, factors affecting the durability of concrete structures, analysis of the entire process of a flexural member under load, and example problems in load-bearing capacity calculation will be extracted from the course content. Students will be divided into groups of 3-5 members, and each group will have 10-20 minutes to present in class. The format of the presentation is not restricted, allowing students to be creative. Videos of the presentations will be recorded and uploaded to the "Chaoxing Learning Platform" for all students in the major to watch and learn.

4.3 Integration of Theory and Practice Teaching Model

The university's "Civil Engineering Talent Training Program" emphasizes that civil engineering students should understand design, be capable of management, and possess construction skills. To promote applied talent cultivation, the university and enterprises should jointly build extracurricular

practical education bases for students, implement a “professional internship, graduation design, job training” tripartite system to facilitate employment, ensuring that students grasp industry foundational knowledge and required skills.

The course involves experiments such as the load-bearing capacity tests of reinforced concrete beams in normal and inclined sections, as well as tests for the load-bearing capacity of reinforced concrete components under compression, tension, and torsion. To reinforce students’ experimental skills, they will be taken to construction sites of collaborating companies for on-site observation of relevant construction processes. This practical exposure aims to improve students’ abilities to analyze and solve specific engineering problems.

Additionally, course design tasks will be assigned, and these can be integrated with some practical projects from local companies. By using actual projects as a background, students’ interest will be sparked. The practical content will include comprehensive practical aspects of concrete structure design, covering component design, load-bearing capacity calculations, reinforcement detailing, and construction measures. The course design tasks will be unique for each student, with similar but not identical topics, cultivating the ability to apply design principles to solve real-world problems effectively.

5. Conclusion

As society continues to evolve, education must undergo reforms to adapt to the changing social landscape. Focused on the training of applied talents in civil engineering, this analysis of the current state of the “Principles of Concrete Structure Design” course has led to discussions on curriculum content and teaching methods. Practical and actionable measures have been proposed to optimize teaching content by dividing it into theoretical foundation and load-bearing capacity calculation modules.

Corresponding teaching methods for each module will assist students in learning and understanding complex knowledge. The adoption of the “identity shift” teaching model aims to create a student-centered learning environment, breaking away from the traditional “teacher lectures, students listen” mode, and fostering students’ enthusiasm for self-directed learning, ensuring that learning is a joyful and progressive experience.

Simultaneously, the creation of an integrated theoretical and practical teaching environment seeks to cultivate students’ ability to solve real engineering problems. Subsequent efforts will involve continuous exploration and innovation to transform “Principles of Concrete Structure Design” into a high-quality course that combines online and offline learning with a unified theoretical and practical approach.

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