

Teaching Reform and Strategy of Civil Engineering Materials Experiment Course under the Background of Low Carbon

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ABSTRACT

With the green low-carbon transformation in the industrial field and the low-carbon development of civil engineering materials, the comprehensive utilization of solid waste is facing serious challenges. Experiments of civil engineering materials in universities should completely break through the restrictions of traditional teaching concepts and models, deepen the experimental teaching of the recycling of solid waste materials and the new method of mechanical property testing, and actively promote the reform of experimental teaching, so as to cultivate high-quality talents for the society. Based on this, colleges and universities can combine the development needs of the civil engineering field of carbon neutrality and large-scale utilization of solid waste, and explore how to form the experimental teaching of civil engineering materials guided by interdisciplinary theory, practical training and practice, so as to improve the teaching quality and effectiveness of this discipline and cultivate high-quality innovative applied talents.

KEYWORDS

Carbon neutrality; Civil engineering materials; Experimental teaching; Innovative applied talents

1 Introduction

"Civil Engineering Materials" is a basic course for civil engineering, engineering management and other majors in higher engineering colleges. The content mainly includes: the basic composition, physical and mechanical properties, quality testing methods and requirements, mix ratio design of sand and stone, cement, cement concrete, steel, asphalt, wood and other materials. Through this course, students primarily acquire the following skills: a solid understanding of the theoretical foundations of civil engineering materials, proficiency in the testing principles and methods of civil engineering materials, the development of practical testing skills, the ability to analyze and address real-world issues, and the capacity to make informed selections and apply building materials appropriately^[1]. This course comprises two primary components: theoretical instruction and laboratory-based teaching. Laboratory-based teaching is crucial for reinforcing theoretical knowledge, fostering innovative thinking, and enhancing students' practical and analytical skills.

However, the current teaching of civil engineering materials testing is predominantly centered on basic and confirmatory testing^[2], which is characterized by material fixation, process regulation, and predictable results^[3]. Throughout the entire experimental teaching process, students are only able to develop a preliminary understanding of the experiment process for civil engineering materials and are in a passive state of learning. They are unable to experience the enjoyment of experimentation and exploration. Consequently, students lack enthusiasm for learning, exhibit a lack of subjective initiative, and their ability to think independently and explore autonomously

cannot be effectively cultivated.

Therefore, this paper aims to address the existing issues in the experimental teaching of civil engineering materials and align them with the societal context of low-carbon development. Through this, reform and innovation will be implemented in the experimental teaching of civil engineering materials, ultimately enhancing students' professional competence and fostering their innovation capabilities.

2 Present Situation of Civil Engineering Materials Test Teaching

2.1 Lag in Curriculum Theory and Experimental Teaching Content

Civil engineering material experiment is a course that combines theory and practice to a high degree. This course covers the basic theory, knowledge blocks, and test skills of civil engineering materials. With the increasing use of new civil engineering materials to meet the needs of social development and complex engineering projects, it is essential to understand the production, composition, performance, influencing factors, technical requirements, material technical standards, quality control, and testing standards involved in experimental teaching content. However, the current experimental teaching content does not adequately reflect the application of new materials and methods. As a result, it lacks innovation and relevance to actual projects which fails to engage students' interest or cultivate their innovative thinking and engineering practice ability. Therefore, in teaching this course we must emphasize understanding these new materials and technologies in civil engineering in order for students to develop innovative thinking throughout their learning process.

2.2 Backward Teaching Methods Currently

The duration of the civil engineering materials course in most universities is 40 class hours (32 theoretical class hours + 8 experimental class hours). The teaching approach for this course emphasizes theoretical instruction and does not prioritize experimental teaching. Furthermore, the traditional experimental teaching method primarily consists of demonstration-based instruction, wherein the teacher explains the experiment's precautions and students follow step-by-step procedures to complete the experiment, collect data, and fill out an experiment report. Throughout this process, there is minimal interaction between teachers and students, which limits opportunities for independent thinking. As a result, there is a neglect of cultivating students' abilities to discover and solve problems through practical application.

2.3 Single Assessment Method

The assessment method for testing civil engineering materials primarily consists of two components: the peacetime results (test attendance rate) and the test report, resulting in a relatively simplistic evaluation approach. However, for civil engineering material tests that do not have a separate course, the test score only accounts for a low proportion of the total course score, approximately 20%, which fails to adequately reflect the significance of experimental teaching. Consequently, this leads to students placing less emphasis on experimental teaching. Moreover, relying solely on conventional metrics such as attendance rates and test reports for evaluating experimental teaching overlooks the importance of process assessment. This oversight hinders an accurate judgment regarding whether students' abilities have been exercised and if their learning outcomes meet requirements. Additionally, it neglects fostering students' ability to identify and

solve problems in practical applications.

3 Reform Strategies for Experimental Teaching of Civil Engineering Materials

3.1 Low-carbon Development of Civil Engineering Materials

The testing of civil engineering materials should be aligned with the requirements of economic and social development, industrial upgrading, and technological progress. The curriculum should be designed with the objective of "informatization, ecology, and multi-dimension".

(1) Informatization: The curriculum places emphasis on both fundamental and professional development. In addition to covering undergraduate teaching content, it also incorporates cutting-edge research findings in civil engineering materials to broaden students' international perspectives and foster their innovative thinking.

(2) Ecological: The curriculum is tailored to meet the strategic needs of national "carbon neutral" initiatives by focusing on new environmentally friendly materials as well as the recycling of construction slag, asphalt, rubber, plastic, and other waste materials. This approach enriches the teaching content while nurturing students' awareness of ecological development in civil engineering materials and their social responsibility.

(3) Multi-dimensional: Aligned with the evolution of the civil engineering industry towards high-altitude expansion, underground development, oceanic expansion, and desert utilization; a multidimensional teaching program is developed for undergraduate education. This aims to cultivate versatile senior technical professionals who can adapt to the demands of construction and development within the civil engineering industry while possessing problem-solving capabilities for complex engineering challenges.

This course is based on the practical education concept of "student-centered and future-oriented" and sets the course objectives (see Figure 1).

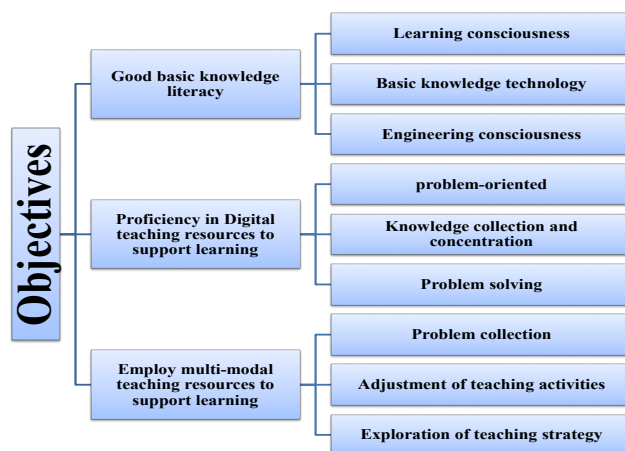


Figure 1 Design of Experimental Teaching Objectives of Civil Engineering Materials

3.2 Optimization of Experimental Teaching Contents and Methods

(1) Multi-scale Testing in Materials Teaching: Currently, the teaching of civil engineering materials testing is focused on a macro level. The innovative approach incorporates microchemical and micromechanical tests, integrating them deeply with mechanical testing to promote continuity and integrity. This approach aligns with the current development trend in materials discipline, helping

students understand the internal mechanisms and enhancing their learning enthusiasm.

(2) Integration of Online and Offline Teaching: Utilizing virtual simulation test platforms, students can learn national standards, observe test demonstrations, and engage in virtual sample preparation, test condition setting, test operation, and data analysis methods online. Additionally, video teachings provide insights into the management system of large instruments and equipment as well as laboratory safety measures. Furthermore, online questioning encourages students to conduct experiments while addressing specific inquiries to enhance their interest and reinforce the objectives of the tests.

Offline teaching involves collaborative completion of a series of solid waste recycling experiments through teamwork. Students have the opportunity to select offline experiment contents based on their interests and expertise while completing sample preparation and performance testing under teacher guidance. This ensures high-quality completion of course objectives in an efficient manner while fostering a sense of teamwork among students.

3.3 Diversified Assessment Methods

Instead of relying on a single evaluation method for ordinary results and test reports, the assessment methods have been diversified. According to the test instructions, students are encouraged to independently search for relevant materials from the library and online knowledge platforms, as well as engage in discussions with teachers regarding experiment design. The test report follows the structure and format of a scientific research project report in order to emphasize innovation and research within the test project, while avoiding uniformity. Course assessment now incorporates a combination of test reports and group defense to facilitate diversified evaluation. This approach takes into account students' actual performance before, during, and after tests, allowing for a comprehensive evaluation of course objectives achievement. In comparison to traditional assessment methods, this approach is more targeted, diverse, effective, and better suited to meet the requirements of engineering education professional certification.

4 Application of Civil Engineering Materials Experiment Teaching

Through continuous teaching reform and personalized instruction, the course "Civil Engineering Materials" aims to enhance students' participation and enthusiasm, ultimately improving the overall teaching quality. As a result of this training, students have demonstrated significant improvement in their professional knowledge and skills related to civil engineering materials. This has been evidenced by their outstanding achievements in various competitions such as Internet +, Challenge Cup, energy conservation, and emission reduction projects. Furthermore, students have actively contributed to the publication of scientific and technological papers, as well as applying for numerous patents. Notably, there has been a substantial increase in both employment rates and postgraduate entrance examination success among our students.

(1) Improved teaching methods have significantly enhanced students' learning enthusiasm: There are many kinds of civil engineering materials, and the course content involves a wide range of knowledge and narrative content. In the teaching process, engineering pictures, cases, accidents and experiment videos are incorporated in a timely manner, and appropriate classroom questions and discussions are conducted, which significantly improves students' participation and learning enthusiasm and makes the course popular among students.

(2) Increase innovative experiments, enrich course assessment, and improve students' practical innovation ability: Based on the routine verification experiment, the research and innovative experiment is included in the curriculum assessment. Students select a topic of relevant materials

involved in the course in groups to do literature review and make a report, cultivate students' speech ability, collaboration ability and team spirit, exercise students' ability to analyze and solve problems with the knowledge they have learned, and stimulate students' interest in scientific research. Students have participated in publishing more than 20 SCI, EI and other scientific and technological papers, exchanging academic reports for many times, and applying for more than 40 patents.

(3) It is essential to regularly update the teaching content, actively participate in discipline competitions, engage with curriculum ideology and politics, and enhance students' literacy. This involves incorporating the latest development trends and research findings in the field of civil engineering materials, inviting industry experts to provide instruction, facilitating thematic discussions, and organizing other activities aimed at helping students comprehend advancements in new materials, technologies, and methodologies. The objective is to foster students' interest in scientific research and encourage their active participation in faculty-led research projects.

5 Conclusion

Currently, the content of civil engineering material experiment teaching lags behind, and there is an urgent need to reform the civil engineering test teaching. This paper analyzes the current situation of civil engineering materials experimental teaching in colleges and universities, and proposes reform strategies for course experimental teaching based on the needs of social development and the requirements of complex engineering projects. These strategies include repositioning teaching objectives, diversifying teaching methods, and implementing diversified assessment methods. The paper also presents the results achieved after the reform of civil engineering materials experimental teaching.

The reform of experimental teaching of civil engineering materials is a long-term task that requires constant updating of curriculum reform measures and innovative teaching methods to meet the needs of social development and engineering projects.

It is essential to actively engage students and teachers in experimental teaching, allowing them to play a significant role in improving students' ability to find, analyze, and solve problems through practical experimentation.

About the Author

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