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Research Article

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Reform and Practice of Teaching "Structural Dynamics and Its Engineering Applications" Based on the OBE Concept

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Abstract

Aiming to cultivate students' practical and innovative abilities prominently. The content has been optimized, and various teaching methods, such as case-based teaching, experimental teaching, and practical software application training, have been established by the Outcome-Based Education (OBE) concept. Based on a blended learning approach that integrates online and offline teaching, student engagement has been enhanced, and their enthusiasm for learning has been stimulated. The course adopts an assessment method that includes "online learning performance, regular class performance, case presentation scores, experimental reports, and final exams," emphasizing process-based assessment to reflect students' shortcomings more objectively. The curriculum reform has effectively improved students' theoretical application and practical innovation capabilities, providing a valuable reference for similar courses.

Keywords: Structural dynamics; OBE concept; Teaching reform; Blended learning

Introduction

"Structural Dynamics and Its Engineering Applications" is a core course for graduate students majoring in Civil and Water Engineering, serving as the foundation for courses and research topics such as structural seismic analysis, structural wind resistance analysis, structural explosion resistance analysis, structural vibration control, and structural health monitoring. With the large-scale construction of flexible structures such as long-span bridges and high-rise buildings, there is an increasing demand for civil and water engineering professionals to have a deep theoretical understanding and engineering intuition in the field of structural vibration. Consequently, the importance of this course in training civil and water engineering students has become increasingly prominent [1].

This highly technical professional foundational course involves multiple research areas such as mathematical modeling, deduction, computational methods, testing techniques, and numerical simulation while also having a distinct engineering and application background [2]. Building upon the structural mechanics knowledge acquired during undergraduate studies, this course further explores the force analysis of rod systems under dynamic loads, laying the foundation for further study in related specialized courses, scientific research, and engineering practice. Upon completion of this course, students are expected to have a profound understanding of the research objects and content of structural dynamics, comprehensively grasp the basic concepts, theories, methods, and ex-

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perimental skills of structural dynamics, and be able to apply the theories and methods of structural dynamics to solve practical engineering problems such as seismic design, isolation (vibration) and vibration reduction.

Several prominent issues have been identified in the teaching of this course. Firstly, students have varying knowledge of prerequisite courses, with some having no prior exposure to dynamics-related courses. Secondly, students struggle to apply theory to practice, and their practical skills have not been adequately developed. Thirdly, a lack of cultivating students' innovative abilities [3]. In response to these issues, as well as the course objectives and teaching content, this course employs flexible and diverse teaching methods and techniques, focusing on cultivating students' application abilities, innovative abilities, and lifelong learning skills.

Reconstruct Course Objectives and Optimize Teaching Content

Based on the school's orientation and the training program for Civil and Water Engineering master's students, we have formulated course objectives that are refined into two levels: basic cognition and advanced cognition, encompassing knowledge, abilities, and qualities. During the teaching process, we first focus on students' mastery of essential cognitive content, such as understanding the fundamental principles and methods of structural dynamics, establishing dynamic models and equations of motion for structures, grasping the dynamic analysis principles and techniques for single-degree-of-freedom and multi-degree-of-freedom systems; and mastering basic skills in structural vibration measurement and dynamic experiments, thereby cultivating students' memory, comprehension, and basic application abilities.

Regarding advanced cognition, we aim to cultivate students' ability to apply structural dynamics theories to structural seismic response analysis, seismic design, and practical engineering projects for isolation and vibration reduction design. This level emphasizes developing problem-solving skills, fostering innovation, and enhancing analysis, research, and problem-solving abilities, as illustrated in Figure 1.

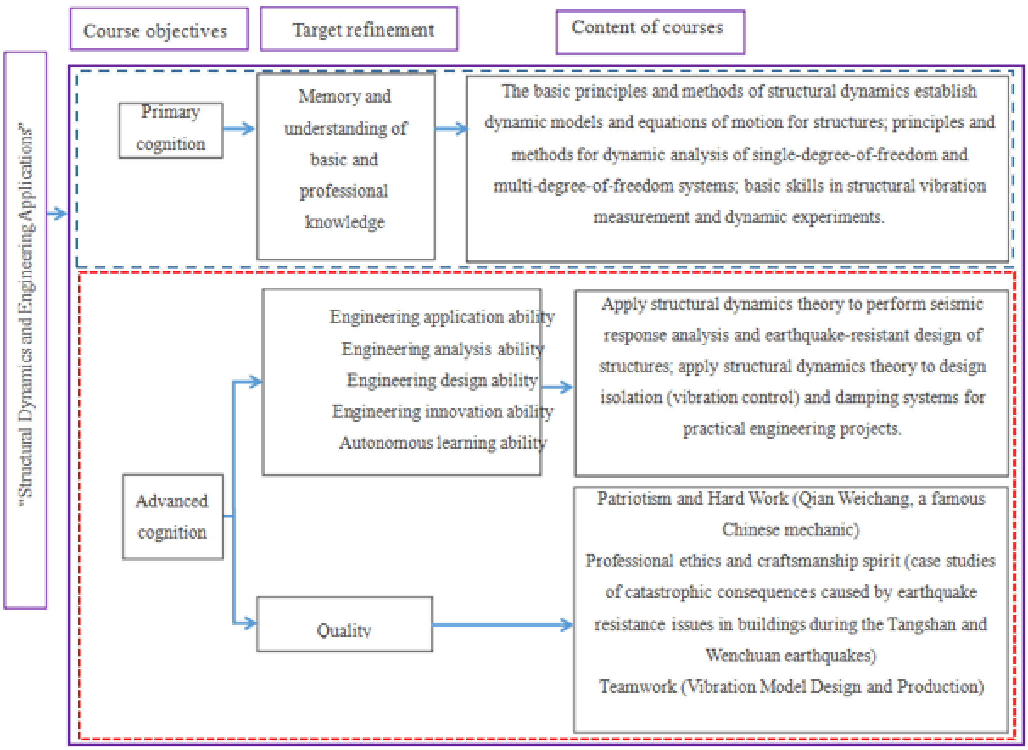

Figure 1: The objectives and content of "Structural Dynamics and Engineering Applications."

Construction of Teaching Methods

Based on the teaching content and requirements for cultivating students' abilities, this course employs flexible and diverse teaching methods and means, including online and offline teaching, case-based teaching, experimental teaching, and practical training in software applications. These methods enhance students' enthusiasm and self-learning abilities and comprehensively train and improve their practical and innovative skills, as detailed in Figure 2.

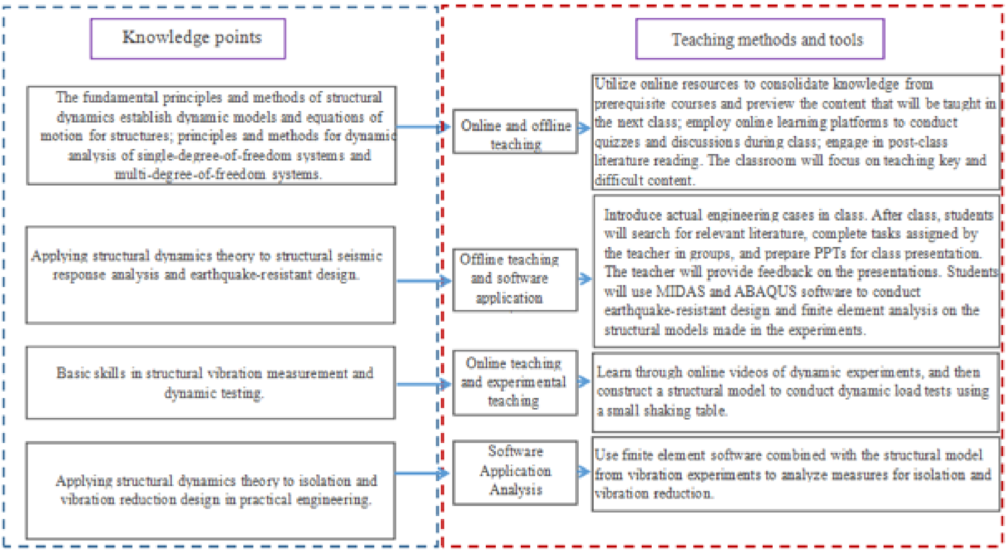

Figure 2: The teaching methods of "Structural Dynamics and Engineering Applications."

Integration of online teaching and classroom teaching

An online teaching resource library that spans three stages—pre-class preview, in-class instruction, and post-class extension - is established, combined with resources from platforms such as China MOOC and Yuban Class, to facilitate a blended learning design that integrates online and offline teaching. Through pre-class resources, students are prepared to enter the classroom with questions and a purpose, guided by the materials to listen to lectures with intention. In-class resources are used to assess students' understanding of the lecture content, while post-class resources strengthen their application abilities, as detailed in Table 1. During classroom instruction, the teacher covers the most fundamental knowledge points required by the syllabus, ensuring the foundational nature of the course content. The main content includes dynamic characteristic parameters, dynamic loads, and forced vibration response analysis for single and multi-degree-of-freedom systems. In-class activities such as thought-provoking questions and quizzes on basic knowledge are designed to assess learning outcomes and further reinforce and supplement weak knowledge points.

Table 1: Online Teaching Resources.

Resource Type	Resource Content
Pre-class resources (primary resources)	The syllabus, teaching plan, chapter tasks, knowledge points outlined in the syllabus, courseware, lesson plans, lecture videos of prerequisite courses, case study videos, vibration experiment videos, etc.
In-class resources (platform resources)	Attendance check, posting of thought-provoking questions, unit testing, assignment releases, course statistics, student management, etc.
After class resources (expanded resources)	Relevant research literature, engineering cases, software operation videos, etc.

Case study

Deeply integrate actual engineering cases with teaching content, encourage students to discuss and ask questions, and create a favorable teaching and discussion atmosphere to recognize the guiding role of structural dynamics principles in engineering practice and deepen their understanding of engineering vibration issues. Introduce engineering problems into the classroom for students to discuss and analyze, clarifying the connection between dynamics-related theories and cases. After class, students are assigned to search for relevant materials, complete tasks, and prepare PPT presentations for class reports. The specific content is detailed in Table 2.

Table 2: Examples of Combining Engineering Practice Cases with Theoretical Explanations.

Specific Methods	Vibration Problem of Guangzhou Humen Bridge Deck [4]	Vibration caused by Blasting Demolition [5]
Engineering problem import	Play the video of Guangzhou's Humen Bridge in 2020, illustrating how lateral wind loads can cause abnormal vibration or even collapse of the bridge deck, highlighting the importance of learning about forced vibration issues.	Play ten famous cases of failed explosive demolitions, showcasing the impact of blasting vibrations on the collapse pattern of buildings, the influence of falling vibrations on surrounding structures, and the significance of impact response issues.
Analysis of the essence of the problem	Through reasonable assumptions, simplify the bridge structure into a continuous/discrete system, conduct theoretical derivation of forced vibration problems, and analyze the influence of structural parameters and external wind load excitation parameters on vibration response patterns.	Through reasonable assumptions and simplifications, the generation and propagation patterns of blasting vibration, recoil vibration, cut closure vibration, primary body collapse vibration, and their hazard levels to surrounding structures are analyzed.
Student PPT presentation and discussion	Guide students to analyze the causes of bridge resonance, discuss measures to avoid amplification of vibration response, and summarize that the overlap between the fluctuation frequency of Karman vortex street caused by wind load and the torsional frequency of the bridge deck is the leading cause of resonance. Measures such as changing bridge frequency, optimizing the fluid configuration of the wind load surface, and increasing the bridge deck's weight can reduce the bridge deck's amplitude.	Guide students in analyzing the influence of different structural parameters on blasting and collapse vibration and determining the relevant calculation formula parameters. To reduce the collapse vibration of the structural body, methods such as lowering the strength of the retained parts or multi-cut blasting can be used to change the structural characteristics so that the peak values of the structural recoil vibration or cut closure vibration increase while the peak value of the collapse vibration decreases.

Experimental teaching

Based on the actual situation of the college and the foundation of the "Earthquake-Resistant Design of Building Structures" course experiment, we will deepen the experiment's content and requirements. Firstly, each group is required to construct a structural model using bamboo skin according to specified dimensions. Secondly, groups must study relevant videos on structural vibration measurement and experiments through online platform resources and conduct vibration experiments on their bamboo skin structural models. Thirdly, groups must submit a design specification that includes the plan's conception, modeling, structural system, simplified calculation diagrams, dynamic response analysis, and other unique and innovative aspects. Finally, each group will select a member to present a PPT report in class, where different groups will ask questions and provide ratings, followed by a review and summary by the teacher.

Software application training teaching

With the development of science and technology, software has become a primary means of structural dynamic response analysis. While mastering fundamental dynamics knowledge, students should enhance their ability to use software to simulate various dynamic conditions that structures may endure, analyze the dynamic responses of structures, and guide the design of actual engineering projects based on the analysis results. The college's BIM laboratory allows students to access licensed finite element software such as Midas and ABAQUS to simulate and analyze structural dynamic responses. Based on vibration experiment models, students utilize finite element software to investigate the effects of different vibration isolation and damping measures, deepening their understanding of vibration isolation and damping principles and grasping the implementation principles of these measures in practical engineering.

Conclusion

This course deeply integrates actual engineering cases with teaching content, making it easier for students to grasp the fundamental theories of the course while enhancing their ability to connect theory with practice. In experimental teaching, students' role-based tasks are increased, and computer application analysis is introduced. Students are not limited to textbooks and theory; their hands-on skills and practical abilities are strengthened. The cultivation of innovation ability is integrated throughout the entire teaching process. Whether it is case teaching, experimental teaching, or software application practical training, innovative elements are incorporated, significantly improving students' innovation ability. Students have affirmed the teaching effect.

Acknowledgement

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Conflicts of Interest

There are no conflicts of interest to declare.

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