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Research on virtual electronic experimental teaching of theoretical mechanics in engineering departments

Lingling CHEN[1*], Zhiyuan WANG[2]

1. School of Civil and Hydraulic Engineering, Bengbu University, Bengbu 233030, China
2. School of Management Science and Engineering, Anhui University of Finance and Economics, Bengbu 233030, China
*Corresponding author
Email address: bbcll2013@sina.cn

Abstract: This study aims to investigate the application and effectiveness of virtual electronic experiments in engineering theoretical mechanics education. By reviewing the current research status both domestically and internationally, the concept and advantages of virtual experiment teaching are analyzed. In addition, the interface and operational process of the virtual electronic experiment are designed and applied to engineering theoretical mechanics classrooms. Through analyzing students' experimental results and learning feedback, the teaching effect is evaluated and improvement strategies are proposed. The aim is to promote the development of virtual electronic experiment teaching in engineering theoretical mechanics, improve teaching effectiveness, and enhance students' learning experience.

Key words: theoretical mechanics for engineering; virtual electronics; experimental teaching

1 Introduction

As a fundamental course in engineering discipline, theoretical mechanics plays a critical role in cultivating students' theoretical foundation and practical ability. However, traditional experimental teaching methods face challenges and limitations due to factors such as time, space, and safety, which restrict students' opportunities to conduct hands-on operations and observe experimental phenomena. To address these issues, virtual electronics experiments have emerged as an alternative teaching method based on computer simulation and modeling technology, which allows students to conduct experiments, observe, analyze, and verify experimental data through a virtual experimental environment and model. This study aims to explore the application and effectiveness of virtual electronic experiments in the teaching of theoretical mechanics in engineering disciplines.

2 Concepts of virtual lab instruction

Virtual laboratory teaching is an experimental teaching method that utilizes computer simulation technology to establish virtual laboratory environments and experimental models, enabling students to conduct experimental operations, observations, and data analysis and validation. Virtual laboratory teaching offers students a safe, convenient, efficient, and cost-effective experimental environment, while mitigating issues such as dangers and high costs associated with physical

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experiments. Instructors can devise various experimental plans and scenarios, manipulating and modifying physical and technical parameters within the virtual environment to meet the experimental needs under different conditions. By employing computer simulation technology, virtual laboratory teaching constructs virtual experimental models based on physical laws and carries out corresponding experimental operations on computer platforms, thus providing a highly realistic virtual laboratory environment that seamlessly integrates with traditional laboratory teaching. This approach provides students with more comprehensive and enriching learning resources, enabling them to gain a more immersive experimental experience, and fostering further exploration and innovation [1].

3 Experiment content and design

3.1 Experimental interface and operation flow design

When designing the interface and workflow for virtual electronic experiments, several aspects should be considered:

(1) User-friendly interface: Ensure that the experiment interface is clear, concise, and easy to understand and operate. Use intuitive graphical interfaces and symbols to allow students to quickly become familiar with and master the use of the experimental platform [2].

(2) Component library and toolbar: Provide a component library that includes common circuit components such as resistors, capacitors, and inductors, allowing students to select the components they need. Additionally, design a toolbar with tools such as connecting wires, oscilloscopes, and signal generators to facilitate circuit construction and measurement.

(3) Drag-and-drop and connection operations: Enable students to drag selected components onto the workspace and connect them using intuitive drag-and-drop and connection operations. This provides flexibility and interactivity in circuit construction through simple and intuitive actions.

(4) Parameter settings and adjustments: Provide functionality to set and adjust the parameters of circuit components. For example, students can input values or use sliders to adjust resistance and capacitance values, allowing them to observe real-time changes in physical quantities within the circuit [3].

(5) Virtual instruments and measurement tools: Design various virtual instruments such as oscilloscopes, signal generators, and digital multimeters, enabling students to simulate signal observation and measurement as with actual instruments. Ensure that these virtual instruments possess commonly used features, such as adjusting time scales and measuring voltage and current.

(6) Real-time data acquisition and analysis: Provide real-time data acquisition functionality to display numerical values of key physical quantities (such as current and voltage) within the circuit. Additionally, design data analysis tools that allow students to process, plot, and analyze the acquired data.

(7) Fault simulation and troubleshooting prompts: Simulate possible faults in the circuit, such as short circuits or open circuits, and provide corresponding fault prompts. Offer assistance and suggestions to students for troubleshooting, promoting their ability to identify and rectify circuit faults [4].

4 Teaching practice and result analysis

4.1 Analysis of students' experimental performance and learning feedback

By analyzing student experiment scores and feedback through a virtual electronic experimental platform, valuable information and guidance can be provided to help teachers and students better evaluate learning outcomes and improve learning methods. First and foremost, analyzing student experiment scores can reveal their actual operational level and understanding of virtual electronic experiments. The platform can record the steps and operational paths of students completing experiments and automatically evaluate the accuracy of their circuit construction and experimental parameter settings. Secondly, analyzing learning feedback can help teachers understand the difficulties and issues that students

encounter during virtual electronic experiments. The virtual electronic experimental platform can record students' operational logs and their questions and doubts during the experiment process. By systematically analyzing student feedback, teachers can identify students' perceptions of the challenges and difficulties encountered during the experiment. This can help determine the teaching focus and strengthen guidance.

4.2 Improving teaching effectiveness and teaching mode strategies

Analyzing the effectiveness of teaching and improving the teaching mode are important steps to enhance the quality of virtual electronic experiment teaching. The following are some improved strategies that can help the teacher to further improve the teaching effectiveness and optimize the teaching mode. Firstly, the teacher can evaluate the effectiveness of the teaching by analyzing the students' experimental results and learning feedback in virtual electronic experiments. If students struggle to understand important concepts or lack skills in operation, the teacher can provide additional explanations and exercises to strengthen the teaching of relevant contents. Secondly, the teacher can consider introducing personalized teaching, setting different experimental tasks and difficulty levels according to the students' actual level and needs. Through personalized teaching, the teacher can better meet the students' learning needs, and stimulate their learning interest and motivation. Finally, to further improve the teaching effectiveness and mode, the teacher can continuously pay attention to updates and improvements of virtual electronic experimental platforms. By keeping up-to-date with the new functionalities and improvements provided by the platform and communicating and collaborating with the platform developers, the latest teaching resources and tools can be applied to teaching practices [5].

5 Conclusion

The study of virtual electronic experiments in engineering theoretical mechanics provides an innovative approach to teaching, breaking the limits of traditional laboratories. By utilizing virtual platforms for electronic experiments, students have the convenience and flexibility to conduct experiments and learn at any time and place. This teaching mode not only enhances students' understanding and application of theoretical knowledge, but also cultivates their practical and problem-solving abilities. The research on virtual electronic experiments in engineering theoretical mechanics will greatly enhance support and propel the learning and development of engineering students.

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Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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