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Research on Teaching Reform of Fundamental Electric Circuit Experiment in Colleges and Universities

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Abstract: The fundamental goal of experimental teaching is to cultivate students' scientific literacy. Colleges and universities put forward three dimensions of experimental teaching objectives focusing on the cultivation of scientific literacy, which is to optimize the experimental content and experimental equipment, pay attention to the quality control of the whole process of experimental teaching, and establish a diversified experimental teaching evaluation model so that the teaching objectives of fundamental electric circuit experiment course is determined. Under the background of education reform, the circuit teaching courses in colleges and universities have been further innovated, put forward to increase the proportion of comprehensive experiments and design experiments, improve experimental equipment and other requirements, and propose to strengthen the quality control of experimental teaching in the early, middle and late stages. This creates the experimental model of the whole quality cycle teaching and increases the proportion of the experiment report assessment. This paper analyzes the key points of teaching reform for fundamental electric circuit experiments in colleges and universities, and then explores the specific strategies of experimental teaching reform, hoping to provide strong support for promoting the experimental teaching reform of fundamental electric circuit experiments in colleges and universities.

Keywords: Fundamental electric circuit experiment; Experimental teaching; Teaching strategies

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1. Introduction

The fundamental electric circuit experiment course is a basic professional course for electrical majors and some related majors. It is the first professional experimental course for college students to establish a connection with subsequent professional courses, such as analog electronic technology, digital electronic technology, high-frequency circuits, and other courses [1]. It is of great significance for students to consolidate theoretical knowledge, cultivate circuit analytical thinking, and solve practical engineering problems. After learning the fundamental electric circuit experiment course, students can effectively consolidate and deepen the study of professional theory, broaden the scope of professional knowledge, strengthen comprehensive thinking, and

cultivate basic scientific research ability and innovation abilities [2].

2. Take scientific literacy as guidance

The first step of experimental teaching is to clarify the teaching objectives. Appropriate experimental objectives dominate the whole process of experimental teaching and plan the correct direction of teaching and learning. The cultivation of scientific thinking and scientific research ability is one of the important goals of experimental teaching. These two contents can be summed up by scientific literacy, and can also be further divided into scientific knowledge, scientific method, scientific attitude, and scientific value [3]. Scientific literacy can be summarized in professional language, which can be explained as follows: the ability to apply scientific knowledge to explain or solve practical problems, to explain natural phenomena, human activities, and their changes, and to give strong evidence.

Based on the above concept of scientific literacy, the goal of experimental teaching can be set as the mastery of the following five contents, including the ability to understand knowledge and apply knowledge; hands-on ability; the ability to conduct experimental inquiry, that is, the ability to observe experimental phenomena, measure data, analyze experimental results, and obtain scientific conclusions; to understand the general methods of scientific inquiry; develop an interest in scientific inquiry. The first four contents point to the experimental teaching objectives in the traditional teaching model focuses on the cultivation of operation ability, exploration ability, and innovation ability. The fifth content points to emotional attitudes and values.

Fundamental electric circuit experiment teaching can also be designed according to the above experimental teaching objectives [4]. Starting from the five objectives of experimental teaching, the teaching model of circuit analysis is formulated, and the experimental content, hardware facilities, experimental steps, and evaluation mode of experimental teaching are designed.

3. Optimize the experimental content and experimental equipment

3.1. Change “confirmatory experiment” to “design experiment”

Cultivation of experimental design ability is one of the important goals of experimental teaching in colleges and universities. Teachers should adjust the experimental teaching model, change the confirmatory experiment to design and comprehensive experiment, increase the openness and exploration of experimental teaching, and strengthen students’ ability to design experiments and analyze experimental results independently [5].

For example, teachers can add the design of a resistance divider, multimeter assembly and debugging, resistance attenuator design, and so on. Taking the design of a resistive voltage divider as an example, students carry out experimental research in groups, design the structure of the voltage divider based on the characteristics of the resistance, select the appropriate magnitude, voltage resistance, and rated power input resistance, and the group test the performance of the resistive voltage divider in a safe environment, and repeatedly optimize the voltage divider to improve its accuracy. In the multimeter assembly and debugging experiment, students draw circuit diagrams and assemble the multimeter based on the experimental equipment, including voltmeter, ammeter, variable resistor, standard resistance box, autocoupling voltage regulator, and DC-regulated power supply, and then conduct experimental debugging. Students complete the whole experiment independently. The independent design experiment can effectively strengthen students’ ability to think independently and solve practical problems and also guide them to develop a rigorous and serious scientific attitude.

The confirmatory experiment and comprehensive design-based content should be reformed. Students’ theoretical understanding ability is cultivated through experiments so that students can consolidate and deepen

their understanding of circuit laws in theoretical courses, and cultivate the ability to use knowledge flexibly. For example, in the component volt-ampere characteristics experiment, increase the content of nonlinear resistance opposite-phase characteristics test. In the virtual experiment, students design the circuit diagram by themselves and test the first-order dynamic circuit time constant, τ [6].

3.2. Promote the experimental teaching hierarchically

The experimental course progresses from simple to difficult step by step. For example, students first carry out simple experiments, such as online simulation experiments, to master Multisim circuit simulation software, scientific computing software Matlab, and carry out some simple online experiments, and then gradually transition to complex experiments, such as carrying out some complex component assembly, circuit simulation analysis and so on [7]. This helps students to strengthen their ability in computer software design and compare and analyze different experiments, understand the internal resistance of power supply, component model, instrument measurement error, component, and lead layout, and strengthen professional ability.

3.3. Optimize the experimental equipment and improve the experimental efficiency

Teachers should shorten the non-technical factors and time in experimental operation and improve the efficiency of experimental teaching. With the increase of circuit components, the circuit structure and data model are becoming more and more complex, and often involve multivariate equations, differential equations, phasor equations, and so on. The calculation work is not only time-consuming and laborious but also error-prone, which affects the subsequent experiments [8]. Therefore, teachers can properly introduce electronic simulation experiments into the class. Simulation experiment has powerful functions such as numerical analysis, matrix calculation, scientific data visualization, modeling, and simulation of nonlinear dynamic systems. Students can apply electronic simulation software to verify the results of calculations and to automatically obtain the results of multivariate equations, dynamic circuit differential equations, phasor equations, and so on. Students can also apply electronic simulation experiments to carry out online simulation experiments. The efficiency of the experiment can be significantly improved by eliminating the practice of preparing experimental materials. For example, the application of EDA software to carry out the design of a digital circuit board greatly improves the efficiency of the experiment, students can directly input circuit schematic graphics and circuit hardware description language in the software to carry out online simulation experiments (**Figure 1**).

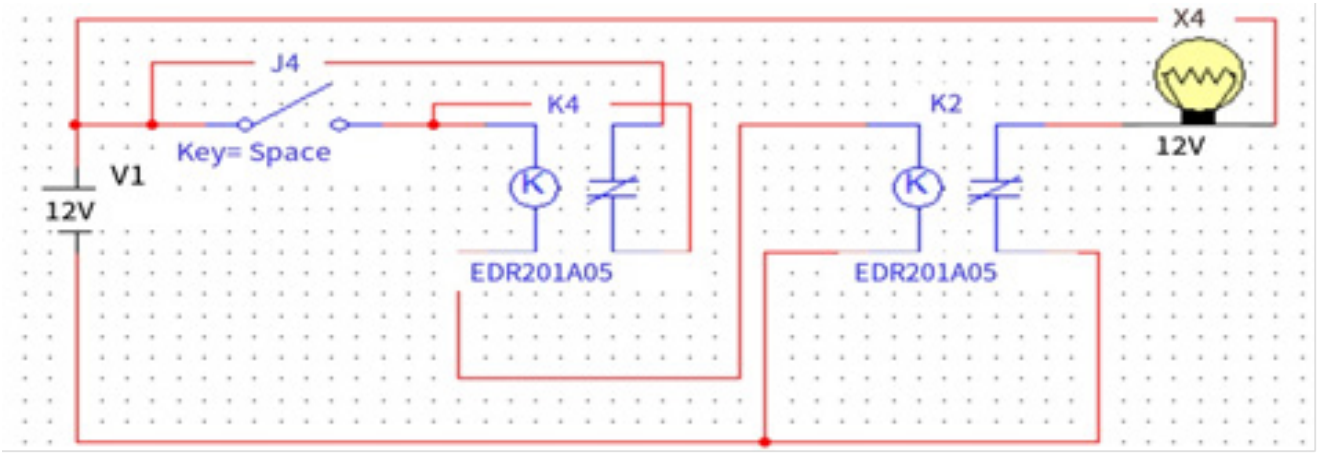

Figure 1. Multisim repeater connection diagram

4. Strengthen the experimental process control

The quality of experimental teaching depends on each step in the process of experimental teaching, which requires teachers to carefully treat each step and carefully design experimental steps.

4.1. Pay attention to details to instill a rigorous and realistic scientific attitude

The essence of experiments is the application of knowledge in practical engineering, so a pragmatic attitude is the foundation of experiments. Therefore, teachers should improve the teaching system and establish a set of standard experimental procedures and systems to help students develop a serious and rigorous scientific attitude and to ensure the authenticity of the experimental data. Students should not modify or even tamper with the experimental data, just because it is "imperfect." Instead, they should focus on analyzing the reasons for errors in data to improve their engineering level. After the experiment, the instructor should check the original data and remind students to find problems. Students should strictly adhere to experimental standards of not touching the bare live conductor with their hands and replacement and live operation is strictly prohibited. The students should check the power supply voltage range before every experiment to ensure personal safety. If the electronic components are found to have a smell of coke, smoke, arc, or other abnormal phenomena, the power should be cut off immediately. After the experiment, put the instrument back to its original position, turn off the power supply, clean the experiment table, wait for the instructor to check, and then leave the laboratory [9]. By paying attention to the details of experimental teaching, students can develop a rigorous and serious style of learning, pay attention to details, start and end well, treat the experiment with the most sincere heart, and build a good scientific research literacy foundation.

4.2. Strengthen the preparation work

Everything should be prepared in advance, as the preview is an important way to improve the quality of teaching. Preview is an effective method to cultivate students' experimental ability, and it is also a bridge of communication between teachers and students. In the process of previewing, students can deeply understand the purpose, content, and steps of the experiment, and effectively master the use of experimental instruments. Capable students can even independently complete design experiments during the preview stage. The preview work consists of two parts. One is to study key content, and the other is to get familiar with the experiment instruments. Students should submit the preview reports so that teachers can assess the key points of teaching according to preview results. Hence, both sides can be more efficient and more targeted in the experimental class [10].

4.3. Strengthen teacher-student communication and interaction

The concept of process-centered and continuous improvement of quality should be established. After the experiment operation is completed, teachers and students discuss the experimental phenomena and experimental results together, find problems, solve problems, or put forward new ideas in the experiment, and write these problems into the experiment report [11]. The analysis of experimental results will be then fed back to improve experimental teaching objectives to form the teaching cycle model.

5. Construct a diversified teaching evaluation system

Based on the three dimensions of scientific literacy, a multiple-teaching evaluation model was constructed. The experimental teaching evaluation was carried out throughout the whole experiment process, and the students were evaluated and encouraged from multiple dimensions to strengthen their sense of gain in learning [12].

Based on the process assessment indicators, different study stage was evaluated, and a certain proportion was introduced in the evaluation results [13]. The confirmatory experiment focused on whether the students complied with operation standards and whether the experimental results were correct. Comprehensive experiments focused on students' understanding and application of comprehensive knowledge, using multiple experimental methods as the carrier. In the design experiment, students designed the experiment scheme, formulated the experimental operation steps, and completed the experiment according to the actual situation [14].

Through the reform of the evaluation subject and content from a diversified perspective, the teaching evaluation system is more scientific and perfect, and the real learning effect of students is reflected. Teachers are prompted to reflect and improve the teaching process. Teachers' evaluation, students' self-evaluation, and students' mutual evaluation were integrated, and the results were weighted according to a certain proportion to obtain a more fair course score. In addition to the basic theoretical knowledge and practical results, the content of teaching evaluation should also include the learning attitude, cooperation spirit, and innovation ability shown by students in the learning process, to realize the comprehensive assessment of students' comprehensive quality [15].

A diversified evaluation system could be constructed based on the concept of individualized teaching, which introduces multiple evaluation indicators and evaluation subjects, innovates the evaluation methods, integrates qualitative and quantitative process evaluation and result evaluation, develops a systematic and comprehensive evaluation work, and ensures the objectivity and fairness of evaluation results.

6. Conclusion

Under the background of education reform, the fundamental electric circuit experiment teaching in colleges and universities should update teaching ideas, apply new teaching models and tools to promote teaching innovation, increase the proportion of design experiments, reflect the student-centered education concept, and strengthen the quality control of experimental teaching in the early, middle and late stages to create a quality experimental teaching cycle model. At the same time, it is proposed to establish a comprehensive evaluation system for students to enhance education effectiveness and obtain more reasonable learning evaluations.

Disclosure statement

The authors declare no conflict of interest

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