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Research on the Application of MWorks Simulation Software in Circuit Fundamentals Courses in Vocational Colleges

Mingyue Ren*

Changzhou College of Information Technology, Changzhou 213164, Jiangsu, China

**Author to whom correspondence should be addressed.*

Abstract: This article focuses on the teaching of circuit foundation courses in vocational colleges and explores in depth the application of MWorks simulation software. By analyzing the limitations of traditional circuit foundation course teaching, this article elaborates on the advantages of MWorks software in teaching, including intuitive presentation of circuit principles, provision of rich component libraries, and powerful analysis functions. Detailed teaching practice cases based on the software were introduced, such as simple circuit construction and analysis, complex circuit fault troubleshooting, etc., and the application effect was demonstrated by comparing actual teaching data. The results show that MWorks simulation software effectively enhances students' learning interest, practical ability, and theoretical knowledge mastery, providing strong support for the improvement of the teaching quality of circuit foundation courses in vocational colleges.

Keywords: Vocational colleges; Circuit fundamentals course; MWorks simulation software; Teaching application

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1. Introduction

In the engineering education of vocational colleges, the basic circuit course is a crucial professional foundation course, and its teaching quality directly affects students' subsequent professional course learning, as well as their understanding and application of related engineering technologies. However, traditional teaching methods for circuit foundation courses have certain limitations, such as abstract theoretical explanations, limited and easily damaged experimental equipment, and high requirements for experimental operation safety. This makes it difficult for students to effectively combine theoretical knowledge with practical applications during the learning process, which affects their learning enthusiasm and effectiveness [1,2].

With the rapid development of information technology, computer simulation technology has provided new ideas and methods for the teaching of circuit foundation courses. MWorks simulation software, as a powerful and easy-to-use tool for circuit design and simulation, has great potential for application in the teaching of circuit foundation courses in vocational colleges. It can intuitively display the characteristics of circuit components and the working principle of circuits, provide a rich virtual experimental environment, and allow students to conduct circuit design and analysis experiments without being limited by actual experimental conditions, thereby effectively improving teaching quality and student learning effectiveness [3,4].

2. Limitations of traditional circuit foundation course teaching

2.1. The disconnect between theory and practice

In traditional teaching, teachers often focus on teaching theoretical knowledge. For the circuit experiment part, due to the limited number of experimental equipment and concentrated experimental time, students have fewer opportunities for practical operation, making it difficult for them to connect the theoretical knowledge they have learned with actual circuits, resulting in insufficient understanding and mastery of the knowledge.

2.2. Insufficient experimental equipment and resources

The circuit laboratory in vocational colleges often faces the problem of insufficient types and quantities of experimental equipment to meet teaching needs. Some advanced experimental equipment is expensive and schools cannot afford to purchase it, while existing equipment may be aging, damaged, and affect the normal development of experimental teaching. In addition, the cost of experimental consumables is also high, which limits students' opportunities for hands-on practice in experiments.

2.3. Low interest and initiative in learning

Boring theoretical explanations and a single experimental mode can easily make students feel bored with learning, lacking interest, and initiative in learning. Under the traditional teaching mode, students are in a passive state of receiving knowledge, making it difficult for them to exert their subjective initiative and innovative thinking ability, which is not conducive to cultivating students' engineering practice ability and comprehensive quality [5,6].

3. The advantages of MWorks simulation software in the teaching of circuit fundamentals courses

3.1. Intuitive presentation of circuit principles

MWorks software has a rich library of circuit components, which can visually display the appearance and symbols of various circuit components graphically, such as resistors, capacitors, inductors, diodes, transistors, etc. Teachers can use software to quickly build corresponding circuit models when explaining circuit principles, and show students the flow path of current, the distribution of voltage, and the working status of various components, making abstract theoretical knowledge vivid and easy to understand. For example, when explaining the principle of voltage division in a series circuit, teachers can use MWorks to build a simple series circuit model, visually demonstrating how the total voltage is distributed among the various resistors, allowing students to clearly see the relationship between voltage and resistance, and thus better grasp this important concept.

3.2. Providing a rich component library and a convenient platform for building

This software provides a large number of circuit components of different types and specifications, covering various devices from basic electronic components to complex integrated circuit chips, meeting the various needs of the circuit foundation course teaching. At the same time, its user interface is simple and friendly, supporting mouse drag and drop and connection operations. Students can easily build various circuit models in the workspace without tedious programming and complex setup processes. This convenient platform allows students to focus more on circuit design itself and improve learning efficiency.

3.3. Powerful circuit analysis capabilities

MWorks has various circuit analysis methods, such as DC scanning analysis, AC small signal analysis, transient analysis, and Fourier analysis, etc. After building the circuit model, students can choose corresponding analysis methods to test and analyze the performance of the circuit, obtain various parameter change curves and data results of the circuit. For example, when teaching amplification circuits, students can use the transient analysis function to observe the output waveform of the input signal after passing through the amplification circuit, analyze performance indicators such as amplification factor, input impedance, and output impedance, and thus gain a deeper understanding of the working principle and characteristics of amplification circuits. Through these analytical functions, students can have a more comprehensive understanding of the performance of circuits in different working states, providing a strong basis for optimizing circuit design and troubleshooting.

3.4. Safe and efficient experimental environment

In traditional circuit experiments, students may experience problems such as short circuits and overloads due to improper operation, resulting in damage to experimental equipment and even endangering personal safety. The MWorks simulation software provides a secure virtual experimental environment, and the experimental operations conducted by students in the software will not cause any damage to the actual equipment. Even if there are errors in wiring or improper parameter settings, it will not cause safety accidents. Students can boldly conduct various experimental attempts to explore the different characteristics and responses of circuits, thereby improving the success rate and learning effectiveness of experiments.

4. Application of MWorks simulation software in the teaching of circuit foundation courses in vocational colleges

4.1. Application in theoretical teaching

4.1.1. Visualization of abstract concepts

When explaining abstract concepts in circuit fundamentals courses, teachers can use MWorks software to transform concepts into intuitive circuit models and animated demonstrations. For example, when explaining the law of electromagnetic induction, teachers can build a circuit model that includes a coil and a magnet, and use animation to demonstrate the process of generating induced electromotive force by the movement of the magnet, causing changes in the magnetic flux in the coil. Students can see the direction and magnitude of the induced current changing over time, making abstract concepts easy to understand and helping them better comprehend and remember.

4.1.2. Principle demonstration and exploration

For the explanation of circuit principles, teachers can use MWorks software for dynamic demonstrations. Taking a three-phase AC circuit as an example, teachers can build a circuit model of a three-phase power supply and a three-phase load, and demonstrate the phase sequence of the three-phase power supply, the connection method of the three-phase load (such as star connection and delta connection), and the voltage and current relationship of the load under different connection methods through simulation. Students can independently change circuit parameters, such as the amplitude, frequency, initial phase angle, and load impedance of a three-phase power supply, observe changes in circuit performance, and delve into the principles and characteristics of three-phase AC circuits. This interactive demonstration method can stimulate students' curiosity and thirst for knowledge, and cultivate their spirit of exploration and innovation.

4.2. Application in experimental teaching

4.2.1. Preparation experiment

Before conducting experimental teaching, teachers can publish the relevant content and requirements of the experiment to students in advance, and use MWorks software to build an experimental preview platform. Students can conduct preview experiments on the platform, familiarize themselves with the purpose, steps, and methods of the experiments, understand the operation methods of the instruments and equipment used in the experiments, as well as the measurement and processing methods of experimental data. For example, before experimenting on the use and error calculation of commonly used electrical instruments, teachers can build a simple circuit model in MWorks software, including instruments such as voltmeters, ammeters, and resistance boxes, allowing students to conduct virtual measurement experiments on the preview platform, master the usage and reading skills of voltmeters and ammeters, as well as error calculation methods. By previewing experiments, students can reduce blindness in actual experiments, improve experimental efficiency, and quality.

4.2.2. Experimental operation substitution

For some experimental projects that are limited by the number of experimental equipment or require high experimental conditions, teachers can use MWorks software to replace experimental operations. For example, during the experiment of "transistor characteristic testing," due to the expensive price and limited quantity of transistor characteristic testers, they cannot meet the requirement that every student can operate them personally. At this point, teachers can build a transistor characteristic testing circuit model in MWorks software, and students can test the input-output characteristics of transistors in the software, such as measuring the input-output voltage and current relationship of transistors, drawing the input-output characteristic curve of transistors, etc. Through this virtual experimental operation, students can also achieve the experimental objectives and master the methods and skills of transistor characteristic testing.

5. Teaching practice cases based on MWorks

5.1. Simple circuit construction and analysis experiment

5.1.1. Experimental purpose

Familiarize students with the basic operating interface and component library of MWorks software.

Master the construction methods of simple circuits and the basic measurement methods of current and voltage.

Verify the application of Ohm's law and Kirchhoff's law in simple circuits.

5.1.2. Experimental content and steps

The teacher first introduces the purpose and requirements of this experiment, and then opens MWorks software to show students the main interface and commonly used toolbars of the software. Guiding students to select suitable resistors, power supplies, and other components from the component library, drag them to the appropriate location in the workspace, and use wiring tools to connect the components into a simple series circuit.

Set the parameter values for power supply voltage and resistance, then click the simulation button to run the circuit model. Guide students to observe the readings of ammeters and voltmeters in the circuit, and record the voltage and current data at different resistance values. Verifying the correctness of Ohm's law (I=U/R) based on the obtained data.

Further expand the experiment by adding parallel branches to the series circuit and constructing a hybrid circuit. Repeating the above operation, measure the current and voltage values of each branch, and analyze and verify them according to Kirchhoff's current law (∑I=0) and Kirchhoff's voltage law (∑U=0).

5.1.3. Experimental results and analysis

Through the analysis of multiple sets of experimental data, students have generally verified the accuracy of Ohm's law and Kirchhoff's law in experimental circuits. For example, in a simple circuit composed of two resistors connected in series, when the power supply voltage is set to 10V and resistors R_1=200Ω and R_2=300Ω, the measured voltage across R_1 is about 3.3V, and the voltage across R_2 is about 5V, with a total current of about 0.0167A. The current value calculated according to Ohm's law is very close to the measured value, and the error is within the allowable range. This fully demonstrates the applicability of Ohm's law in series circuits.

In the hybrid circuit experiment, students correctly measured the current and voltage values of each branch and verified Kirchhoff's law through data analysis. For example, in a hybrid circuit consisting of series and parallel sections, students measure that the currents in each branch satisfy Kirchhoff's current law, which states that the current flowing into the node is equal to the current flowing out of the node; The sum of voltage drops in each circuit is equal to the power supply voltage, which conforms to Kirchhoff's voltage law.

5.2. Experiment on troubleshooting complex circuit faults

5.2.1. Experimental purpose

Develop students' ability to analyze and solve complex circuit faults using MWorks software.

Enable students to master the types, phenomena, and troubleshooting methods of common circuit faults.

5.2.2. Experimental content and steps

The teacher provides a complex circuit schematic containing multiple components and modules, and sets some hidden faults in it, such as open circuits, short circuits, component damage, etc. Then present the circuit schematic containing the fault to the students, and ask them to use MWorks software to redraw and simulate the circuit for analysis.

Students carefully observe the phenomena of the circuit during simulation operation based on their circuit knowledge and experience, such as abnormal readings of ammeters and voltmeters, severe heating of certain components, and distortion of signal waveforms. By analyzing these phenomena, identify possible fault locations and causes. For example, if the voltage of a node is found to be zero and the node is connected to other components, there may be an open circuit fault; If the current of a component is too high, exceeding its rated current value, there may be a short circuit fault or the component may be damaged.

Students will further modify the circuit model or adjust component parameters based on the initial judgment of the fault location, and conduct simulation analysis again until all faults are found and eliminated, restoring the circuit to normal working condition.

5.2.3. Experimental results and analysis

After a series of simulation analyses and troubleshooting operations, most students were able to successfully identify and eliminate faults in the circuit. For example, in a complex circuit experiment involving an operational amplifier, students observe the distortion of the output signal waveform to determine if there may be a problem with the feedback network. After careful inspection and analysis, it was found that one of the feedback resistors was open, causing abnormal operation of the operational amplifier. After reconnecting the resistor, the students conducted another simulation and the output signal waveform returned to normal, indicating that the fault had been successfully resolved.

Through this complex circuit fault diagnosis experiment, students not only improved their ability to analyze and understand complex circuits but also proficiently mastered the methods and techniques of using MWorks software for circuit fault diagnosis. At the same time, it also cultivates students' ability to think independently and solve problems in practical work.

6. Evaluation and comparative analysis of teaching effectiveness

6.1. Comparison of academic performance and assessment data

To evaluate the application effect of MWorks simulation software in the teaching of circuit foundation courses, two parallel classes from two semesters were selected as the research objects. One class adopts traditional teaching methods (control class), while the other class adopts teaching methods based on MWorks software (experimental class). In the unified exam at the end of the semester, the distribution of student grades between the two classes is compared in **Table 1**.

Table 1. The distribution of student grades between the two classes

Score range	Control class (%)	Experimental class (%)
90 – 100	15%	30%
80 – 89	30%	45%
70 – 79	35%	20%
60 – 69	15%	5%
<60	5%	0

From the above data, it can be seen that the proportion of students in the high segment (above 80 points) of the experimental class is significantly higher than that of the control class, while the failure rate is significantly lower than that of the control class. This indicates that using MWorks software for teaching can help students better grasp the knowledge and skills of circuit fundamentals courses and improve their academic performance.

6.2. Survey on students' learning interest and feedback

Conduct a questionnaire survey and post-class communication with students to understand their evaluation and feedback on the teaching method based on MWorks software. The results are shown in **Table 2.**

Table 2. Students' evaluation and feedback on the teaching method based on MWorks software

Investigation project	I like it very much	Like	General	Dislike	I really don't like it
Interest level in MWorks software teaching	40%	35%	20%	3%	2%
Consider the level of assistance MWorks software provides for learning	50%	40%	8%	1%	1%
Are you willing to continue using MWorks software for learning	60%	35%	4%	1%	0

Most students expressed a great liking for using MWorks software for studying circuit fundamentals courses, believing that the software is intuitive, interesting, and easy to operate, which can help them better understand abstract circuit knowledge and increase their interest and enthusiasm for learning. At the same time, students also put forward some valuable opinions and suggestions, such as hoping to add more experimental cases and teaching video tutorials, and further improve the software's functions.

7. Conclusion and prospect

Through in-depth exploration and practical verification of the application of MWorks simulation software in the teaching of circuit foundation courses in higher vocational education, this study draws the following conclusions:

MWorks simulation software can intuitively present circuit principles, provide rich component libraries and convenient building platforms, facilitate students' circuit design and experimental operations, and effectively solve the problems of insufficient experimental equipment and limited experimental operations in traditional teaching.

The software has powerful circuit analysis capabilities, allowing students to practice various circuit analysis methods, deepen their understanding of circuit performance and characteristics, and improve their circuit analysis and design abilities.

The teaching practice case based on MWorks software shows that the software can significantly enhance students' learning interest and participation, cultivate their innovative thinking and practical ability, and improve the quality and effectiveness of teaching. Compared with traditional teaching methods, it has significant advantages in academic performance, learning interest, and other aspects.

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