

# *Research on Low-cost Digital Teaching in Electrotechnical Experiments*

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**Abstract:** Today, with the development of digital teaching, virtual simulation has the advantages of high security, controllability and repeatability, strong sense of experience, and remote operation, and it has a wide range of application space. However, due to the large investment cost in the early stage of its construction, it is currently mainly used to assist experimental teaching, and there are still many experimental courses that cannot achieve high-level digital construction through virtual simulation. This paper studies the digital construction of electrical engineering experimental courses under low-cost conditions, and makes use of the advantages of MOOCs to build a good and rich theoretical foundation platform to provide students with sufficient preview materials and extended knowledge combined with practice. Use Flash to make simple virtual simulation experiment GIFs, show the basic operation process of the experiment facing each other the students in advance, which can be used for students' pre-class preview and after-class review; Make high-quality experiment operation videos for students to learn the details of experiments. In the process of research, we pay attention to combining experiments, students, teachers, costs and other factors to explore the digital construction path that suits us.

## **1. Introduction**

Digital teaching is to make use of modern computer technology, network technology and other modern educational technologies to realize the sharing of educational resources in a digital way. By adopting the interactive computer network technology in the multimedia classroom, students can conveniently use the abundant information resources on the network to complete a series of teaching processes from preview to review, from in-class to out-of-class, from classroom to out-of-classroom learning. This teaching method can well solve the problem that teachers difficult to teach and students difficult to learn in traditional teaching, totally change the situation of students passively accepting knowledge, and realize the fundamental transformation of teaching mode from "teaching" to "learning". On March 25, 2022, Vice Minister Wu Yan of the Ministry of Education delivered a speech with the theme of "Digital Empowerment, Demonstration and Leading to Build a High-quality Education System 'Pilot Zone'", proposing to fully implement the strategic action of education digitalization and build a new digital system of higher education with Chinese characteristics. The extensive use of digital information technology in university teaching and

digital teaching have become a hot research topic in the field of education in China.

## **2. Research Status of Digitalization of Electrotechnical Experiment**

Electrotechnics is a basic course for engineering majors in universities. It has a wide range and strong practicality. And its experimental teaching plays a very important role in the whole teaching system. Experiment teaching is an important link to train students' basic theories and experiment skills, and improve their ability to analyze and solve problems. However, in the practical teaching, the electrotechnical experiment has the expansive safety requirement, plus the problems of the sites, the equipment and the teachers, which usually makes the experiment teaching students can only have one hands-on chance, even if all the principles are very clear, it is difficult to complete all the experiment steps at one time. The digital transformation of the experimental course of "Electrotechnics" and then combining it with multimedia technology can effectively solve the problems existing in traditional experimental teaching. [1,2]

At present, the most popular experiment digitization is to carry out virtual simulation, which has great help for experimental teaching and can enable students to have a plurality of simulation operations. If combined with practical experiments, virtual simulation can not only help students preview in advance, so that students can master the experimental process more proficiently through practice, so that they can successfully complete experimental teaching in practice, and also facilitate students to review multiple times after practice, which is more beneficial to help students master the experimental principles. However, virtual simulation development is expensive, so there is no guarantee that most lab courses will be virtualized. How teachers can carry out digital research on electrical engineering experiments under low-cost conditions according to the actual situation is the focus of this paper. [3,4]

## **3. Paths to Realize Low-cost of Electrotechnical Experiment**

### **3.1. Strengthen the preview of experimental theories by making full use of MOOCs and Learning Pass**

Before the start of the experimental course, MOOC resources for the experimental course can be established on the school website for students to preview before class; Establish a learning pass of this experimental course on the teaching platform for students to learn and discuss during and after class. Through MOOCs, students can preview experimental theories in advance and understand the experimental principles; Before the start of the experimental courses, the learning pass of the experimental courses can be established on the learning pass for students to study and discuss during and after class. Through MOOCs, students can combine experimental theory with practice to improve students' comprehensive ability; In MOOCs, some typical engineering cases can be displayed, such as steady-state operation of DC motors, starting and braking of three-phase asynchronous motors, etc. Through learning MOOC, students can improve their self-directed learning ability and spirit of exploration; Through the use of MOOCs, experiments traditionally taught by teachers and listened to by students, can be turned into learning modes in which the students explore, research and solve problems by themselves, which can improve students' self-learning ability. Through the use of MOOCs, the teaching level of teachers can be improved; Through the application of MOOCs, teachers can design their own teaching content, teaching methods and means in a set of standard and standardized lesson plans; Through the support of MOOCs, teachers can choose multimedia courseware suitable for their own teaching characteristics according to their actual situation; Through the guidance of MOOCs, teachers can carry out the reasonable design of teaching plans, teaching links and teaching content during teaching; Through

the recordings MOOCs, teachers can videotap, record, and produce courseware for content that they can't explain clearly in class or that students have more questions. MOOCs can enable more communication between teachers and students and promote teaching reform; Through the channels of MOOCs, teachers can counsel and answer questions to students from different perspectives; Through the MOOC platform, students can interact with other students in online discussion forums.

### **3.2. Making Simple Virtual Simulation with Flash Animation Production**

Flash software is a very powerful animation production software produced by Adobe Company. It has the characteristics of simple operation, unique design style and rich expression forms. It is widely used in the fields of web page design and multimedia production. The powerful function of Flash determines that it can do a lot of animation. Animations are displayed on the screen frame by frame, with each frame consisting of a continuous image rather than a static picture. When playing, the image will gradually zoom in, zoom out, blur over time, until it disappears. It has animation design function, script creation function, timeline tool, special effect editing function and other functions. The use of Flash to make electrical experiments to achieve simple virtual simulation has the advantages of low price, relatively simple production and good effect. Making an electrician experiment with Flash requires the following steps:

#### **3.2.1. Preliminary Investigation**

The content and purpose of the experiment need to be clear. Before designing the virtual experiment platform, it is necessary to define the content and purpose of the experiment so as to determine the required functions and simulated objects. This is helpful to design a targeted virtual experiment platform.

The appropriate Flash development tools need to be selected. When selecting Flash development tools, consider the stability, usability and functionality of the development tools, such as Adobe Flash, FlashDevelop, etc.

Data sources and formats need to be identified. The data source required by the virtual experiment platform can be experimental data, literature data or simulation data. The data source and format shall be determined for data processing and display in the design. [5,6]

#### **3.2.2. Design Implementation Measures**

Design style and layout need to be determined. When designing the interface of the virtual experiment platform, the design style and layout should be determined according to the experiment contents and the characteristics of the students. Aiming at the low-cost virtual simulation design, the virtual experiment platform shall be concise and clear in interface, clear in function layout and easy to operate.

Virtual experimental environment needs to be constructed. When constructing virtual experiment environment, the Flash technology shall be used to realize the simulation of virtual experiment environment, such as establishing virtual laboratory and virtual equipment.

Interactive features need to be developed. In the virtual experiment platform, students need to conduct the experiment operation, so it is necessary to develop interactive functions, such as mouse click and drag, to simulate the experiment process.

Data processing and display functions need to be implemented. In the virtual experiment platform, it is necessary to process and display the experimental data, such as data collection and data analysis. The Flash technology is needed to realize the visualization of the data. [7,8]

### 3.2.3. Flash Animation Production

Flash animation for virtual simulations of electrician experiment can include the following sections:

Selection of experimental equipment: An experimental equipment selection menu on the start page can be set to allow students to select the required equipment freely and display the related name, picture and function of each equipment.

Experimental procedure demonstration: The composition of the circuit, the connection mode and the current flow direction can be demonstrated through animation to help students better understand the concept of current. At the same time, the working principle of the circuit can be demonstrated through the use of electric motors, light bulbs and other equipment.

Experiment parameters adjustment: An interactive circuit parameters adjustment page can be set. Students can adjust the circuit parameters by dragging the slider or entering numbers, such as voltage and current, etc., and observe the changes of the experimental results in real time.

Experiment record sheet: a sheet for recording experiment data can be made, including test time, circuit parameters, experiment results, etc., so as to facilitate the students to record and analyze the experiment data, and could export the record sheet to facilitate the students to report after class.

After the students learned and mastered, the fault detection and maintenance can be added. A fault detection and maintenance interactive page can be made, and the students can carry out fault detection by themselves and carry out circuit maintenance according to the prompts, thereby improving the practical operation ability of the students.[9,10]

### 3.2.4. Optimization and Improvement

Flash animation production needs to carry on the concrete operation according to the actual situation, the producer's technology level and many other factors. For the design that is difficult to realize can be bypassed for the time being, and just let the whole effect present, it shall be improved continuously in the future teaching. Flash is used to make a preliminary product, which is continuously improved in combination with the feedback of students. Under the existing conditions, increase the human-computer interaction as much as possible to allow students to further understand the teaching steps.

## 3.3. Producing of High Quality Experiment Process Video

Although virtual simulation can impart key knowledge to students in principle and steps, it is different from practical operation after all. For how most students can achieve better teaching effect through the only once experiment operation chance in college, it is necessary to make the same learning contents as the practical operation environment and steps. That shall help students better complete experimental learning, truly master relevant skills, and integrate the spirit of craftsmanship.

The recording of the video needs to clearly and unambiguously show the more detailed steps, the specific operation requirements of each step and the reasons therefor, etc., to help students deeply understand and truly master the video content. Before shooting the video of the experimental process, it is necessary to carefully design the experimental protocol, break down the experiment into individual steps for shooting, and ensure that the experimental process can be fully recorded. At the same time, it is also necessary to arrange the sequence of experimental steps reasonably to facilitate post-video editing. When shooting a video of the experimental process, it is necessary to adjust the shooting angle appropriately, so that the picture shows as many key points in the experimental process as possible, as well as the use of experimental equipment, to help students

better understand the experimental process. Post-video editing: After the shooting is complete, post-video editing is required, including video editing, audio processing, subtitle addition, etc., to present the experimental process more comprehensively. At the same time, you can also add appropriate explanations or text instructions to facilitate students' understanding of the content of the experiment.

The teaching of Electrician Experiment can't be separated from the operation of actual experiment. Students' practical ability must be improved in practice. No virtual simulation technology can completely replace the actual operation. But adding the contents of digital teaching into the experiment, and making full use of digital technology can improve the efficiency of experiment, reduce the risk of experiment, improve the effect of students' character preview, make full and reasonable use of practical instruments, and also be beneficial to the consolidation and strengthening of the knowledge for students after class.

#### 4. Summary and Prospect

In this paper, three aspects are proposed for the production of simple virtual simulation using MOOCs, Flash animation, and high-quality experimental process videos. In terms of MOOCs, through the form of online courses, students are provided with a more flexible and convenient way to learn, and at the same time, they can break the limitations of time and space, so that students can benefit more in electrician experimental education. In terms of Flash animation production, the process of actual circuit experiments is simulated in the form of virtual simulation, so that students can have a deeper understanding of circuit principles and experimental operations. In terms of high-quality experimental process video production, the use of experimental equipment and key points in the experimental process are displayed in the form of videos, so as to facilitate students' understanding and mastery of experimental content.

In the future, with the continuous development of technology, the electrotechnical experiment teaching will also be continuously improved and perfected. For example, virtual reality, augmented reality and other technologies can be used to construct a more realistic circuit experiment environment to improve students' practical operation ability. At the same time, aiming at different learning groups, more innovations and attempts can be made in the teaching content and form, so as to make the electrician experiment teaching more vivid and interesting, and improve the students' learning enthusiasm and effect. In a word, the future of electrotechnical experiment teaching shall be full of hope and opportunity.

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