Transactions on Computer Science and Intelligent Systems Research
ISSN: 2960-1800, eISSN: 2960-2238 | Volume 1
AIEA 2023

# A Brief Analysis of the Implementation Mode of Virtual-Reality Integration Experiments in Electronic Technology

Xinwei Gao [1, a, *], Weili Liu [2, b], Dongqiu Xing [1, c], Jingna Cui [1, d], Lihua Qi [1, e]

[1] School of Information and Communication Engineering, National University of Defense Technology, China

[2] Central Theater Command General Hospital of the People's Liberation Army of China, Wuhan, Hubei, 430035, China

[a, *] duanyi012345@163.com, [b] 576157596@qq.com, [c] Angelaxing @126.com,

[d] 897731741@qq.com, [e] lihuaqizhf@126.com

* Corresponding Author: Xinwei Gao

**Abstract.** Electronic technology encompasses a wide range of knowledge areas, which can be somewhat dispersed. There are certain pain points in terms of course organization, teaching team composition, and the allocation of teaching hardware facilities. Traditional hands-on courses in electronic technology heavily rely on real-world experimental environments. If offline teaching cannot be conducted, it can significantly affect the quality of course delivery. Therefore, leveraging virtual laboratory technology to achieve a combination of virtual and real-world experiments becomes essential. This approach enhances the diversity of teaching methods, effectively alleviates the teaching burden, and aims to achieve the rational allocation of teaching resources and enhance teaching effectiveness.

**Keywords:** Electronic Technology; Virtual Experiments; Virtual-Reality Integration.

## 1. Introduction

Electronic circuit components are complex and diverse, characterized by nonlinearity and certain parameter variations. Analog electronic components exhibit nonlinearity and parameter dispersion. The input-output relationships in analog circuits are continuous, diverse, and complex. Digital circuits operate with different logic level ranges based on device characteristics. Test instruments are inherently non-ideal, and parasitic parameters within electronic circuits, as well as external electromagnetic interference, can significantly impact circuit characteristics under certain conditions. Therefore, laboratory experiments in electronic technology demand high-quality experimental conditions and skills. Traditional experimental teaching systems heavily rely on real-world experimental environments, making it challenging to meet students' experimental learning needs in situations like a pandemic.

To cultivate comprehensive practical skills in university students, it is essential to prioritize experimental teaching and improve the conditions for conducting experiments. Virtual experiments, as an effective complement to traditional experimental teaching, have become a vital means to enhance the quality of experimental teaching. They not only alleviate the pressures many universities face in terms of funding, facilities, and equipment but also break free from the time and space constraints of traditional experiments. Students and teachers can access virtual laboratories online anytime, anywhere, and operate instruments and equipment for experiments. This approach enriches the types of experiments, enhances the quality of experiment completion, and may even have a transformative impact on experimental teaching. Conducting virtual experiments requires an understanding of the concept, characteristics, and applications of virtual experiments, a review of the current status of virtual experiments both domestically and internationally, a glimpse into the future of virtual experiments, exploration of the technologies and scenarios for virtual experiments, and an evaluation of the practical effects of virtual experiment teaching. Therefore, in-depth research into the implementation mode of virtual-reality integration experiments in electronic technology is of practical significance.

## 2. The Current State of Development in Virtual Experimentation Technology.

Virtual experimentation is a mode of experimentation that has evolved and developed with the use of multimedia, simulation, and Virtual Reality (VR) technologies. It originated in the late 20th century and revolves around the use of computers as the central control unit. It utilizes software technology to construct logical structural models of systems, coordinates related hardware technologies to form virtual experiment systems, and connects these systems through computer networks to create a networked virtual experiment environment[1]. From this, it can be understood that virtual experimentation is not simply an extension of a single technology but rather an amalgamation of various technologies, including computer technology, virtual reality technology, human-computer interaction technology, and more. Virtual experiments are built upon a virtual laboratory environment, focusing on the interactivity of experimental operations and the simulation of experimental results. They can also be integrated with real-world equipment to enhance the realism of the experiments.

Looking at the emergence and development of virtual experimentation technology, it can be broadly categorized into three phases

1.The first phase

The first phase of virtual experimentation is the computer simulation stage. During this phase, people primarily utilize the computer's exceptional data processing capabilities to process experimental data. There is a greater emphasis on the logical and deterministic aspects of experiments, with minimal involvement of the experiment operator.

2.The second phase

The second phase of virtual experimentation is the virtual reality stage. By employing virtual reality technology, it is possible to create virtual simulated experimental environments and objects for experimenters. Experimenters utilize computer technology, multimedia technology, and programming skills to design or modify experimental procedures. Virtual laboratories can present the experimental process and results to experimenters in a more intuitive and visual manner.

3.The third phase

The third phase of virtual experimentation is the holographic virtual reality stage. In this stage, more advanced technologies are applied to virtual simulated laboratories. Experimenters can enter the constructed virtual experimental scenes using specific equipment. They can manipulate the scene by using interactive devices such as data headsets, gloves, or rigid exoskeleton suits. Experimenters have the ability to control various objects within the scene, such as experimental equipment and objects, allowing for a more comprehensive and immersive participation in experimental activities.

Virtual experimentation technology is mainly categorized into four major types: immersive virtual reality technology, image-based virtual technology, integrated technology for experimental environments and virtual experiment platforms, and network-based virtual technology. Virtual experiment systems are typically divided into desktop virtual experiment systems, immersive virtual reality systems, augmented reality-based virtual experiment systems, and distributed virtual experiment systems. Virtual experiments not only serve as teaching platforms for conducting experimental teaching but also investigate and assess students' experiences in virtual experiment learning. This has led to the optimization and improvement of teaching models and platforms, enabling the presentation of various experimental scenarios in a short period of time, enhancing experimental efficiency, and giving rise to the concepts of virtual laboratories and virtual research laboratories.

## 3. The Implementation of Virtual-Reality Integration Technology in Electronic Technology.

The integration of technologies such as system simulation, virtual reality, and multimedia with real-world experimental equipment is gradually moving towards a state of seamless integration, leading to the concept of virtual-reality integration in experimental teaching. This integration is a product of the deep fusion of discipline expertise and information technology. It represents an essential method for conducting online experiments in laboratory-based courses. The development of virtual-reality integration encompasses aspects like the creation of experimental teaching resources, the establishment of platforms for shared teaching management, the formation of teaching management teams, and the development of management systems. It follows the principles of combining the virtual and real, ensuring practicality, and mutual complementation. Virtual laboratories are a significant implementation method of virtual-reality integration, utilizing various technologies such as virtual instruments, virtual reality, databases, networks, and real-time computer control to create a virtual experimental environment for experimenters.

Currently, various approaches have emerged in the design and implementation of virtual-reality integration experimentation technology:

1. A virtual reality simulation mechanism based on Java/VRML Script: VRML provides an external interface to drive 3D objects created within it for simulation programs. Due to VRML's network capabilities, it offers JAVA classes as an external application interface (EAI). By using external classes, users can gain control over the system browser object. A simulation package based on JAVA can be integrated with VRML files within an HTML page to display the process of simulation animation. The simulator performs the simulation work and dynamically drives the operation of entities in the virtual world.

2. A virtual reality simulation mechanism based on Creator/Vega and C++: Vega provides specialized modules for building three-dimensional entities and driving scenes. These specialized modules are placed in a C++ environment, allowing seamless integration between C++-based simulation programs and the Vega environment. During program execution, the bound Vega modules enable virtual reality simulation within that environment.

3. A virtual reality simulation mechanism based on OpenGL/C++ simulator: Similar to other means of implementing virtual reality simulation, combining OpenGL and C++ involves developing the simulator using C language and integrating it with OpenGL's graphics development capabilities to create a comprehensive virtual reality simulation system.

4. Internet + Electronic Technology Basic Experiment Platform

With the support of network management software and operating platforms, students can use a client browser to real-time configure and control hardware circuits, set excitation parameters for experimental circuits, select test points, and perform real-time measurements with virtual instruments. This platform effectively resolves conflicts between laboratory availability and students' experiment schedules. Students can complete course experiments remotely, engage in design and innovation, overcome the limitations of a single experiment mode and fixed content, choose to expand the experiment content, stimulate students' enthusiasm for experimentation, meet individualized needs, and reduce the maintenance and management workload for teachers. The laboratory becomes truly open, enhancing teaching effectiveness. Theoretical course instructors can use real-time projection to demonstrate various characteristics of actual devices, compare the pros and cons of circuits under different operating states and conditions. Multiple courses are integrated to guide students in understanding the roles of their learned courses. Real instrument panels help consolidate students' instrument operation skills. The specific configuration is as follows:

(1) Transmission Medium: Network;

(2) Experimental Circuit: Remote Experimentation Platform (Actual Components, Actual Circuits, Real Data);

(3) Operating Platform: Client Browser.

5. Online Board Architecture

Online experimentation platform configuration includes multiple online experiment cabinets, a set of online experiment network management platform, a set of online experiment operating platform, and network equipment (such as servers). The board architecture essentially integrates all the circuits from traditional experimental setups, the analog (or logical) switching matrix required for electronic connections, virtual testing instruments, and communication and control circuits onto a single board (multi-layer PCB). When students engage in remote experiments, the online experiment network management platform establishes a data link between the student's PC terminal and the online board. The network management platform continuously forwards commands from students, such as circuit construction, circuit parameter adjustments, signal testing (virtual instrument operations), to the experiment board. The control circuit (processor) on the experiment board receives the relevant commands, switches the analog (or logical) switching matrix (completing the construction of the experimental circuit), and real-time collects and sends back data from the experimental circuit nodes for display and analysis by virtual instruments on the backend (student's PC).

Many typical examples of virtual-reality integration have emerged. Tsinghua University has established an electrical engineering teaching experiment system based on virtual instruments and conducted research on a unified platform for remote computer hardware experiments. Zhejiang University has established a hardware cloud experiment platform that seamlessly integrates virtual and real components, supporting computer system-related courses. National University of Defense Technology has developed cloud-based experiments, providing hardware support for remote online experiments.

Currently, research on virtual-reality integration teaching models in electronic technology practical courses has made significant progress. It can address issues like insufficient experimental equipment and restricted experimental conditions, achieving resource sharing and remote control effects. However, the degree of virtual-reality integration still requires further improvement, and the connection between practical operations and virtual experiments needs to be strengthened. Overall, virtual-reality integration experimentation technology is in a phase of rapid development.

## 4. Management and Assurance of Virtual-Reality Integration Experiments

In accordance with the "Notice on the Construction of National Virtual Simulation Experiment Teaching Centers" (Jiao Gao Si Han [2013] No. 94), the construction of virtual simulation experiment teaching centers adheres to the guiding principles of "scientific planning, resource sharing, emphasis on key areas, efficiency improvement, and sustainable development." This framework provides direction for the management and assurance of virtual-reality integration experiments. In the context of "virtual simulation experiment teaching," several important technological characteristics are present: "It should make use of essential information technologies such as virtual reality, multimedia, human-computer interaction, databases, and network communication, and may also include other significant technologies[2]."

The construction of the Virtual Simulation Experiment Teaching Center should focus on four main aspects: virtual simulation experiment teaching resources, the management and sharing platform for virtual simulation experiments, the teaching and administrative teams, and the establishment of a management system. The management and sharing platform can either be innovatively developed in-house or adapted from imported solutions. The teaching and administrative teams of the center are integrated with those of the demonstration center but may have additional requirements in terms of their structure, competence, and experience to meet the needs of virtual simulation experiment teaching. In terms of the management system, the Virtual Simulation Experiment Teaching Center should rely on the corresponding national-level experimental teaching demonstration centers to establish a sound personnel, organizational, and institutional framework, promoting the standardized and efficient operation of the center.

Currently, some experimental course management platforms have achieved capabilities such as experiment process management, visualization of virtual experiments, configuration of portal platforms, and specialized equipment configuration. For instance, the online experiment network management platform and operating platform can manage hardware resources, experiment processes, device management, and online experiment operations. The specifics are as follows:

1.Online Experiment Network Management Platform

In terms of hardware resource management, it dynamically allocates and establishes data links between hardware modules and client devices, forwards control commands, and manages experimental data. For experiment management, it allows teachers to upload experiment courseware, set student experiment permissions (time and content), publish experiment announcements, grade experiment reports, and provide assistance. For students, it supports experiment previews, experiment reservations, schedule inquiries, grade inquiries, and question submissions. Regarding equipment management, it maintains records of the performance of experimental equipment and tracks equipment utilization.

2. Online Experiment Operating Platform

Upon logging into the online experiment platform via a web browser, users can access hardware resources. They can also review experiment objectives, principles, content, procedures, and precautions. The platform supports online experimentation, enabling users to build experimental circuits, set experimental parameters, and perform real-time testing using virtual instruments. It embeds virtual instruments such as triple-output power supplies, function signal generators, multimeters, 4-channel oscilloscopes, and 8-channel logic analyzers. Additionally, it allows for remote loading of software for digital system design and algorithm performance testing. Users can access and store experimental circuits and data, as well as design and upload experiment reports.

A professional virtual-reality integration experiment platform can integrate teaching resources, support cross-course series experiments and interdisciplinary experiments, and accommodate various experiment modes (analog, simulation, online, real). It also facilitates online development and sharing. It offers control over the experiment process in areas such as experiment management, experiment step control, experiment result analysis, experiment process tracking, experiment interaction modes, and comprehensive experiment evaluation. For instance, systems employing B/S architecture technology allow users to access the management platform through a web browser. They can view relevant functions (software lists, course lists) and statistics (learning records, exam scores) and initiate 3D simulation projects. Teachers can organize simulation exams and theoretical exams through the platform. Students can interact with teachers, share learning experiences, take course notes, and participate in exams through the platform. It simplifies resource sharing and simulation operations for both teachers and students, along with unified personnel and grade management, making teaching work more networked and information-driven. Electronic technology comprehensive experiment platforms that utilize remote virtual-reality integration technology come with network management and operating platforms. Administrators can manage all daily affairs of remote virtual laboratories, including user management, course management, laboratory configuration, experiment content editing, experiment scheduling, and announcement management. Teacher users can publish and manage announcements, set student experiment permissions, tutor students in experiments, and grade experiment reports. Student users can reserve experiment times, access experiment courseware, perform experiment operations, test experiment results, upload experiment reports, and view grades.

In conclusion, in the development and construction research of virtual-reality integration experiment platforms, management and assurance work is crucial.

## 5. Conclusion

In the process of laboratory teaching, the effective use of virtual-reality integration experiment technology can significantly improve experiment efficiency, enable remote collaboration, and promote resource sharing. This technology not only addresses issues related to the shortage of experimental instruments, outdated experiment content, and outdated experimental techniques but also opens up new avenues for open-ended experiment teaching modes. Virtual-reality integration experiments in the field of electronic technology provide a new theoretical basis for the construction of blended online and offline courses, enhance the development system of electronic technology courses, lead research on electronic technology teaching cases, accelerate the aggregation and refinement of high-level teaching outcomes, and comprehensively elevate the quality of electronic science course instruction. Furthermore, the development of electronic information technology in medical education and medical applications is closely linked. For example, in psychological intervention practical teaching, "the experimental group adopted the virtual-reality integration practical teaching mode, while the control group used scenario simulation teaching methods. The results showed that the experimental group's psychological intervention practical assessment scores, deep learning approach, and overall learning experience evaluations were significantly higher than those of the control group".

Therefore, in-depth research and application of virtual-reality integration experiments have become an important direction for strengthening laboratory construction, reforming experimental teaching methods, and expanding the application of electronic technology.

## References


[1] Du Yining. Research Status of Virtual Experiments and Their Significance in Teaching. Journal of Zhejiang Ocean University (Natural Science Edition), 2020(7), 391.

[2] Department of Higher Education, Ministry of Education. Notice on the Construction of National Virtual Simulation Experiment Teaching Centers, August 13, 2013.

[3] Gao Yun, Li Xiaohua, Su Qian, Wang Lifang, Zhou Ying. Implementation of Virtual-Reality Integration Practice Teaching of Nursing Undergraduates' Nursing Psychological Intervention. Journal of Nursing, 2023(8), 87.