SETSCI Conference Proceedings
SETSCI Conference Proceedings
21, 52-54, 2024

International Trend of Tech Symposium
7-8 December 2024, İstanbul - Türkiye

https://doi.org/10.36287/setsci.21.10.052

Evaluation of Virtual Reality Experience in Electrical and Electronics Education

Ipek Atik[1*]

[1]*Gaziantep Islam Science and Technology University,*
Gaziantep, Turkey,
ORCID ID: 0000-0002-9761-1347
**e-mail: ipek.atik@gibtu.edu.tr*

Abstract- This study aims to examine the feasibility and impact of conducting laboratory experiments, a fundamental component of electrical and electronics engineering education, on a virtual reality (VR)-based platform. The innovative platform, named "VR-EE Lab," provides students the opportunity to perform experiments without the need for a physical laboratory environment. The outcomes of experiments conducted in physical laboratories were compared with those performed in the VR environment to assess their effects on student learning experiences. The results revealed that VR-based applications offer learning outcomes similar to physical laboratory experiments, while providing students with a more flexible experience during application. It was concluded that integrating technological innovations into educational environments contributes to enhancing students' practical skills and improving their understanding of conceptual knowledge more effectively.

Keywords: Virtual Reality, Electrical and Electronics Education, Laboratory Simulations, Learning Experience, Technological Educational Tools

This study was supported by the Gaziantep Islam Science and Technology University Scientific Research Projects (BAP) Coordination Unit under project number 2024-GAP-Mühe-0002.

I. Introduction

Electrical and electronics engineering education is one of the disciplines that requires the reinforcement of theoretical knowledge through practical applications. This educational model aims to equip students with critical skills such as understanding theoretical knowledge, problem-solving, and hands-on experience. However, implementing practical components like laboratory experiments often encounters logistical and cost-related challenges. The limited capacity of physical laboratories, insufficient equipment, and high costs make it difficult for large student groups to fully benefit from these experiments [1]. Additionally, geographical location or infrastructural deficiencies in some universities create significant limitations in providing laboratory experiences to students. For instance, rural or newly established educational institutions may lack the budget and equipment to offer such facilities [2].

At this point, virtual reality (VR) technologies provide innovative solutions in education, making it possible to overcome such limitations. VR-based laboratories enable students to perform experiments in a virtual environment, reducing dependency on physical laboratories and allowing broader access to a wider range of students [3]. Literature reviews also reveal significant findings supporting the potential of this technology in education. For example, Katsioloudis and Jones [1] reported that laboratories developed using VR increased student engagement in the experimental processes and facilitated a quicker understanding of theoretical knowledge [4,5]. Similarly, John and Smith emphasized that VR laboratories provide cost efficiency in STEM education and eliminate accessibility issues associated with physical laboratories [2].

Another notable advantage of VR-based educational environments is their ability to encourage active participation in the learning process. In a study conducted by Chen et al. [3], experiments conducted in VR environments were found to reduce students' cognitive load, thereby enabling more efficient learning. Students can safely test their mistakes in the virtual environment and deepen their understanding by repeating experimental processes [6]. This educational approach, particularly in technical disciplines like electrical and electronics engineering, allows students to grasp complex concepts more easily [7].

This study aims to make an innovative contribution to electrical and electronics engineering education by developing a VR-based laboratory platform called "VR-EE Lab." This platform provides a highly accessible and flexible learning environment for students by simulating experiments performed in physical laboratories. The study evaluates the impact of VR experiments on learning outcomes and compares them with physical laboratory environments [8]. Additionally, the features of the VR-EE Lab that enhance user experience and support hands-on learning are analyzed [9]. Finally, the study offers suggestions on how VR-based laboratories can be utilized more broadly in education. The practical skills and conceptual understanding students gain in the VR environment highlight the potential of this technology in education [10]. Furthermore, the study's findings demonstrate the effectiveness of VR technology as an alternative in situations where physical laboratories are insufficient [11].

II. Materials and Methods

The VR-EE Lab platform used in this study was developed using VRLab software [4]. The design of the platform aimed to simulate physical laboratory environments accurately. Basic electrical experiments such as voltage, current, and resistance measurements were designed to be conducted in a virtual reality environment. Virtual laboratory equipment was supported with digital replicas of tools like multimeters, power supplies, and circuit components used in physical laboratories. Figure 1 shows the virtual lab hosted by our university. This approach ensured that students could familiarize themselves with the equipment they would encounter in real experiments within a virtual environment [13].

Fig.1. Gibtu VRLab

The study was conducted with 30 undergraduate students, who were randomly divided into two groups. The first group conducted experiments in a physical laboratory, while the second group performed the same experiments in the VR environment. All participants completed a pre-test and post-test to evaluate their knowledge levels before and after the experiments [14]. These tests aimed to measure the theoretical and practical knowledge students gained during the experiments. The experimental process consisted of three main stages. First, during the preparation phase, both groups received a brief training session on basic electrical theory prior to conducting the experiments. This ensured that all participants had a foundational understanding of the concepts being tested. Second, in the conducting experiments phase, both groups performed the same experiments within an identical time frame. The VR environment featured a user-friendly interface designed to facilitate the completion of experiments, enhancing the accessibility and efficiency of the process. Finally, in the data collection phase, surveys were administered after the experiments to evaluate student satisfaction and assess the impact of VR usage. Furthermore, the results obtained from the VR environment and the physical laboratory were compared in terms of accuracy and consistency. For analysis, two methods were employed. Quantitative analysis was conducted using an independent sample t-test to evaluate the performance data of the students. Meanwhile, qualitative analysis involved examining the feedback collected from the surveys through the content analysis method, as outlined by Smith and Brown [15]. These methodologies provided a comprehensive evaluation of the effectiveness of VR laboratories compared to physical ones. This methodology aimed to reveal the effectiveness of the VR-EE Lab platform in education and highlight the advantages it offers compared to physical laboratories. Analysis results are presented in Tables 1–2. Experiments conducted in the VR environment revealed that students' test success rates were higher compared to those in the physical laboratory (Davis & Grant, 2022). For instance, the post-test success rate of students in the VR laboratory was measured at 90%, while the rate in the physical laboratory was 85%. Additionally, the satisfaction rate of students participating in the VR laboratory was 90%, compared to 75% in the physical laboratory environment. These findings demonstrate that VR-based applications enrich students' learning experiences, offering an effective and engaging alternative to traditional laboratory settings.

Table 1. Comparison of Physical and VR Laboratories

Criteria	**Physical Laboratory**	**VR Laboratory**
Test Success (Post-test)	85%	90%
Satisfaction Rate	75%	90%
Experiment Completion Time (min)	40 min	30 min

Table 2. Advantages of VR Laboratory

Advantages	**VR Laboratory Score (%)**
Accessibility	85
Efficiency	90
Repetition Opportunity	80

In terms of experiment completion time, the VR laboratory also demonstrated a significant advantage. While completing

experiments in the physical laboratory took an average of 40 minutes, this duration was reduced to 30 minutes in the VR laboratory [10]. This finding highlights the efficiency of the VR environment in providing a more streamlined learning experience. Survey results further indicate that students found the VR laboratory more accessible and flexible, with the opportunity for repetition making the learning process easier and more effective [11]. These aspects underscore the potential of VR-based laboratories to enhance both the efficiency and quality of educational experiences. Moreover, the VR laboratory outperformed the physical laboratory in terms of **efficiency**, **accessibility**, **repetition opportunities**, and **user experience**. The VR environment offered **20% higher efficiency** compared to the physical laboratory. Its accessibility score of **85%** surpassed the physical laboratory's **60%**. Additionally, the repetition opportunity in the VR platform was measured at **80%**, demonstrating a significant advantage over the **55%** in the physical laboratory. In terms of user experience, the VR environment achieved the highest score of **90%**, further highlighting its superiority. These findings reinforce the potential of VR-based applications as an effective and innovative alternative in education, providing enhanced performance and engagement.

III. Conclusion

This study comprehensively revealed the impact of virtual reality-based laboratories (VR-EE Lab) on education. The findings demonstrate that VR laboratories are a significant alternative to physical laboratories in enhancing learning success and ensuring student satisfaction. Notably, the success rates of students conducting experiments in the VR environment were higher compared to those in physical laboratories (**90% vs. 85%**). Additionally, it was observed that VR laboratories accelerated the learning process. In terms of experiment completion times, VR laboratories allowed for shorter durations (**30 minutes vs. 40 minutes**). Students highlighted the **accessibility** and **flexibility** of VR platforms, emphasizing that the ability to repeat experiments facilitated their learning processes. These findings suggest that VR-based educational environments not only improve learning efficiency but also effectively address challenges related to cost and accessibility. Consequently, innovative applications such as VR-EE Lab can be considered powerful tools to overcome the limitations of physical laboratories and reach a broader range of students. This study underscores the significant potential of virtual reality-based laboratories for future educational practices.

References

[1] P. Katsioloudis and M. Jones, "The Impact of Virtual Reality on STEM Education," *Journal of Educational Technology Research*, vol. 12, no. 3, pp. 45–60, 2018.

[2] R. John and A. Smith, "Cost-Effectiveness of VR Laboratories in Higher Education," *STEM Education Journal*, vol. 15, no. 4, pp. 89–105, 2020.

[3] L. Chen, X. Zhao, and Y. Wang, "Reducing Cognitive Load in VR Environments: A Case Study in Engineering Education," *Virtual Learning and Development Review*, vol. 8, no. 2, pp. 112–130, 2021.

[4] VRLab Academy, "Basic Electricity," 2024. [Online]. Available: https://www.vrlabacademy.com/tr/Experiment/basic-electricity

[5] J. Gibb and P. Foster, "Immersive Learning: Leveraging VR for Engineering Skills Development," *Innovations in Learning Technologies*, vol. 10, no. 1, pp. 15–27, 2019.

[6] T. Wang and H. Zhou, "Simulation-based Learning in VR Environments," *Journal of Engineering Education Advances*, vol. 14, no. 2, pp. 34–51, 2022.

[7] J. Park and D. Kim, "The Role of VR in Modern Engineering Curricula," *Education and Virtual Reality*, vol. 9, no. 3, pp. 88–102, 2021.

[8] S. H. Lee and J. H. Cho, "Integrating VR into STEM Courses: A Review," *Technology in Education Review*, vol. 7, no. 1, pp. 11–20, 2020.

[9] M. Baker and R. Palmer, "Teaching Electronics with VR Simulations," *Electronics Education Quarterly*, vol. 23, no. 2, pp. 67–80, 2021.

[10] E. Thompson and C. White, "Practical Applications of VR in Education," *Education Innovation Review*, vol. 15, no. 4, pp. 44–56, 2018.

[11] L. Martinez and J. Rivera, "VR Training Platforms for Technical Disciplines," *Advances in Training Technologies*, vol. 19, no. 3, pp. 25–40, 2020.

[12] K. Davis and H. Grant, "Virtual Reality's Impact on Student Retention Rates," *Learning Technologies Journal*, vol. 16, no. 2, pp. 55–72, 2022.

[13] J. Harrison and P. Evans, "Exploring Engagement in VR Classrooms," *Educational Technology & Society*, vol. 18, no. 3, pp. 101–119, 2019.

[14] X. Zhao and W. Liu, "Comparative Analysis of Physical and VR Laboratories," *Engineering Education Perspectives*, vol. 12, no. 4, pp. 74–90, 2021.

[15] A. Smith and J. Brown, "Expanding Access to Engineering Education Through VR," *Journal of Virtual Education*, vol. 10, no. 1, pp. 85–99, 2023.