Applying Virtual Labs with The Technology of Video Games: Student Satisfaction

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ABSTRACT

The laboratory is a crucial aspect of electrical engineering education. Through participation in laboratory activities, students can develop practical skills such as design, interaction, and creative thinking. Technological advancements have led to the introduction of virtual laboratories. This study explores the application of 3D virtual labs using video game technology and presents the results of a student satisfaction survey regarding the learning methods employed to support laboratory courses. A quasi-experimental research design with a single group pre-test and post-test was employed, involving seventy-three electrical engineering freshmen. The findings indicate that 3D virtual labs integrated with visual, text, and sound feedback features can enhance user satisfaction and support laboratory courses. The use of 3D virtual labs with video game technology applications that provide these feedback features can help electrical engineering students better understand electrical and electronic circuits, leading to positive student satisfaction. The suggested methodology could potentially be applied to similar educational software applications beyond electrical engineering, encompassing various fields of science and engineering.

Keywords: *virtual labs, student satisfaction, engineering education*

1. INTRODUCTION

Laboratories are a crucial component of educational institutions in preparing students for careers, particularly in engineering education. Practical laboratories have been indispensable since the beginning of undergraduate education [1]. Practical experience utilizing actual tools and equipment in the laboratory is a vital element of education, particularly in engineering education. Therefore, practical instruction using real tools in lab settings is a crucial element of engineering education [2]. Engaging in lab work, students foster the growth of practical competencies, including problem-solving, collaboration, curiosity, and innovation [3].

It is well established that enrolling learners in conventional laboratory work is an efficient method of acquiring the necessary skills. Hands-on laboratories are equipped with every necessary tool, and learners are physically present within the lab [4]. By participating in these courses, learners gain hands-on experience, observe authentic equipment and setups, and engage directly with materials or equipment. This active participation enhances their skills and understanding of concepts.

Nevertheless, physical laboratory infrastructures are expensive. Advancements in technology and science necessitate the replacement of outdated tools. Educational institutions frequently substitute outmoded laboratory equipment because they cannot afford to acquire costly resources. Additionally, outdated tools can pose safety risks. Instructors often encounter challenges when attempting to conduct hands-on laboratory work due to limitations in laboratory facilities [5], [6]. These limitations include the high cost of laboratory equipment and materials, potential hazards, the responsibility associated with using instruments, and the recurring requirement of instructional time to set up conventional experiments.

To mitigate the challenges associated with physical laboratory settings, computer-based virtual laboratories [7] may be proposed as a viable substitute [8], ensuring both safety and cost-effectiveness. Unlike physical labs, virtual laboratories are lower in cost. Within these virtual laboratories, students can perform experiments, analyze results, and engage in study participation at any time and from any location. The ability to observe phenomena that are not tangible in reality, such as electrical current, is an

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additional significant benefit of virtual laboratories [9]. The quality of virtual lab technology is an important factor in the educational setting [10]. This research introduces 3D virtual labs, which use video game technologies and provide visual, audio, and text feedback features. It also investigates student satisfaction with implementing these virtual labs to support their practical courses.

2. LITERATURE REVIEW

2.1 Virtual labs

Laboratory work holds significant importance as a learning component in numerous domains, particularly in practical and technological disciplines like engineering [11]. It is recommended that students allocate the majority of their study time to resolving practical challenges [12]. One potential strategy for addressing the constraints imposed by physical facilities and infrastructure is the implementation of virtual laboratories as supplementary components for practical exercises [13]. Virtual laboratories have the potential to educate experts across various disciplines; however, they hold particular significance for young engineers, given the critical nature of the experiential element in engineering education [14]. Virtual laboratories operate using software and training simulations. Within this environment, students have access to replicated models of devices and tools, in addition to visual and auditory representations of tangible tools and devices [15].

2.2 Student Satisfaction

One of the primary objectives of education is student satisfaction. Higher levels of academic achievement and increased motivation to learn are typically associated with student satisfaction with their educational experience. Educational institutions should prioritize the delivery of high-quality instruction that is pertinent to student requirements to enhance student satisfaction [16]. Additionally, a conducive and encouraging educational setting equipped with sufficient resources and recent technology contributes to heightened student satisfaction [17].

Incorporating technological advances into today's educational institutions can profoundly influence student satisfaction as learners become more engaged with using technology [18]. Learners' ability to interact with the technology interface is a significant determinant of their satisfaction. Learners experience greater satisfaction with their education when they are actively involved and invested in the process [19]. When learners are provided with technology-enhanced educational resources, they demonstrate superior academic performance. Conversely, those denied these resources demonstrate lacking academic performance [20]. It was additionally observed that incorporating technology has a beneficial effect on student satisfaction, promoting participation and facilitating successful learning throughout the course [20], [21].

3. METHOD

This investigation aimed to determine the impacts of virtual laboratories with video game technology on student satisfaction in laboratory courses offered by the Electrical Engineering Department. We employed a quasi-experimental research design with a single-group pre- and post-test for this purpose. A total of 73 freshmen students participated in this study. Figure 1 displays the interface of the virtual labs used in this study. The researchers administered modified student satisfaction questionnaires from Lund (2001) to all participants before and after the learning activities. Pearson's correlation analysis and Cronbach's alpha ($\alpha = 0.940$) showed that the questionnaire was valid and reliable. However, the normality test result ($s = 0.932$, $p < 0.05$) indicated that the data was not normally distributed. Therefore, this study uses the Wilcoxon signed-rank test to determine the impact of virtual laboratories on student satisfaction.

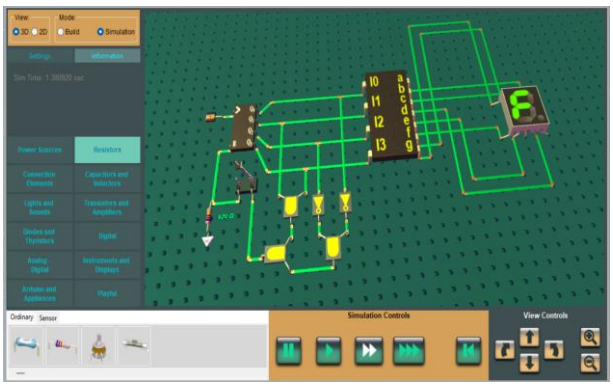

Figure 1. Interface of virtual laboratories

4. RESULT

The purpose of this investigation was to determine the effects of virtual laboratories on student satisfaction. A Wilcoxon Signed Rank Test was applied to determine whether there were any differences in the levels of student satisfaction before and after treatment. According to Table 1, the average student satisfaction score before the learning treatment using virtual labs was 3.3151, and after the treatment, it was 4.3219, resulting in a mean difference of 1.0068. This indicates that learning using virtual labs enhance students' sense of satisfaction.

Table 1. Descriptive Statistics of students' satisfaction

Variable	N	Pre-test		Post-test	
	73	M	SD	M	SD

Student Satisfaction		3.3151	0.81119	4.3219	0.61588

Table 2 shows that the negative ranks between student satisfaction for the pretest and post-test are 9. A value of 9 indicates that there were nine student scores that decreased from the pretest to the post-test. The mean rank, or average decrease in value, is 12.89, while the sum of ranks is 116. The positive ranks between student satisfaction for the pretest and post-test are 58. There are 58 positive data points, which means that 58 students experienced an increase in satisfaction from the pretest score to the post-test score. The mean rank, or average increase in value, is 37.28, while the sum of ranks is 2162. Furthermore, ties represent the similarities between the pretest and post-test scores. These ties refer to six student scores that are identical between the pretest and post-test results. The results of statistical tests using the Wilcoxon test in Table 2 show a significance value of < 0.001 ($p < 0.05$). Therefore, we can conclude that there is a significant difference in student satisfaction before and after using virtual labs with video game technology.

Table 2. Results of Wilcoxon test for students' satisfaction

Variable		N	Mean Rank	Sum of Ranks	Z	*p*
Student Satisfaction	Negative Ranks	9[a]	12.89	116.00	-6.403[b]	.000***
	Positive Ranks	58[b]	37.28	2162.00		
	Ties	6[c]				

***$p < 0.001$

5. DISCUSSION

This research investigated the impact of virtual labs with video game technology on student satisfaction. The results indicated that student satisfaction increased after the experiment (Table 2). This finding aligns with previous studies. Virtual labs offer numerous advantages that can enhance student satisfaction by allowing students to work at their own pace and revisit experiments as needed (flexibility). Students can conduct experiments without risks, and the ability to make mistakes without real-world consequences encourages experimentation, deeper understanding, and an engaging learning environment [23]. Interactivity: Virtual labs often include interactive elements such as videos, animations, and simulations that can illustrate complex concepts in a more digestible manner. The ability to simulate real-world scenarios contributes to a deeper understanding of complex concepts [24]. Many virtual labs provide instant feedback on students' actions, helping them understand concepts more quickly and effectively (feedback). Student learning at their own pace is beneficial for those who need more time to understand concepts [15]. High-quality simulations in virtual labs can closely mimic real-world scenarios, providing practical experience applicable to real-life situations (real-world application).

6. CONCLUSION

In this study, we investigated student satisfaction after using a virtual laboratory with video game technology to support a lab course. According to the research results, student satisfaction with using virtual labs incorporating video game technology increased. Students appreciate the interactive and immersive elements that video game technology provides, which makes the learning experience more engaging and enjoyable. This technology allows for more realistic and detailed simulations, helping students better understand complex concepts. Features such as sophisticated graphics, direct feedback through text, sound, and visuals, and dynamic simulation scenarios increase student engagement and learning motivation. Overall, students enthusiastically welcomed the use of virtual labs with video game technology, expressing increased satisfaction due to the innovative and effective learning experiences it provided

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