The Impact of the Virtual Laboratory on Students' Attitudes in a General Physics Laboratory

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Abstract—The purpose of this study is to investigate the impact of the virtual laboratory experiences on attitudes towards physics laboratories. It also aims to determine the opinions of students' in terms of the virtual laboratory. The study involved 42 students who were divided into two groups (21 treatment, 21 control). Students were randomly assigned to both groups. In the research, the pre-test and post-test control group design was used. The treatment group used the virtual laboratory. On the other hand, the control group used the physical laboratory. The research data were obtained via the "physics laboratory attitude scale" and semi-structured interviews. The result of this study demonstrate that the virtual laboratory experiences had positive effects on the students' attitudes. Additionally, semi-structured interviews determined that they had positive opinions regarding the virtual physics laboratory experiences.

Keywords—virtual laboratory, physics laboratory, physics, attitude.

1 Introduction

Inventions in the field of science within the 21st century have accelerated technological developments which in turn have contributed to the development of countries [9]. Countries which do not want to fall behind in the technological competition have focused on raising analytical and productive individuals who are well educated in the basic sciences [4]. However, among these basic sciences, physics is the most challenging for students [2]. The main reason for this is most physics concepts are abstract [10].

In physics courses it is crucial that abstract concepts are related to real life events, boring mathematical problems are eliminated and the weight of lab practice is increased [5], [15]. The laboratory which enables permanent learning is a method where students learn through performing tasks individually or in small groups and experiencing [12]. However, physical laboratories aren't able to be used efficiently due to reasons like not every school having one, their cost to set up and maintain and the lack of equipment [21]. When students cannot comprehend the theoretical information trying to be given through a lab experiment, they memorise it and as a result, they fail the course. Students having experienced failure develop negative attitudes towards the course [22]. At this point, in order to resolve the difficulties, virtual laboratories were resorted to [22].

Simulations are a technology used with an educational purpose which is to transform theoretical knowledge into skills [17]. They are software programmes which replicate the basic components of the real world to provide controlled learning environments [6], [14]. There are many educational advantages of using virtual laboratories which are a viable alternative to physical ones [17]. Some of these are; implementing time-consuming experiments in a shorter period of time, carrying out dangerous experiments in a safe environment, recreating events that would be impossible to observed in physical laboratory in a virtual environment, being an alternative solution for costly laboratories, enabling students to progress at their own pace, providing students with immediate feedback so that they can check their learning [19], [16], [17], [21], [22], [8], [26].

In literature, there are many studies on using virtual laboratories for physics lab courses [18], [24], [7]. This study evaluates the views of students on virtual laboratories. These students were studying at the department of science teaching, the department of physics teaching and high-school. Yet, it is believed that the views of students studying computer education and educational technologies on the subject are also important because they are actually educated to implement the integration of technology into learning environments and to establish the effective usage of technology both by teachers and students. Review of the related literature did not reveal any related research evaluating views of computer and technology teaching candidates on virtual laboratories. Within this context, the the research questions of this study are:

2 Methodology

This study was conducted using a mixed-method approach making use of both quantitative and qualitative methods. The study's quantitative data was obtained via a physics laboratory attitude scale and the qualitative data was obtained via semi-structured interviews.

2.1 Participants

The study participants consist of a total of 42 students enrolled in the Department of Computer Education and Educational Technologies and who were taking the Physics-II course.

2.2 Data Collection Tools

Physics Laboratory Attitude Scale: In the study, the physics laboratory attitude scale developed by [20] to evaluate student views on physics laboratory course, was used. The scale is likert type ranging from 1 (strongly disagree) to 5 (strongly agree). The reliability coefficient of the scale is 0.90. The scale consists of a total of 27 items which of 21 are positive and 6 are negative. Obtaining a high total score from the scale shows that the participants had positive views on the physics lab and obtaining a low score shows that they had negative ones.

Semi-structured Interviews: In order to determine participant views on the physics lab course activities carried out via the virtual laboratory, the researcher held semi-structured interviews. After a five-week experimental process, 16 volunteer participants from the experimental group were asked to give their views on the virtual laboratory activities. To make sure that there was no loss of data during the interviews, they were recorded and later transcribed. To keep interviewed participant's identities anonymous, they were coded from S1 to S16.

2.3 Data Analysis

Before the experimental process, in order to determined whether there was an equivalence in attitude towards the course, the experimental and control group participants were given the physics laboratory attitude scale as a pretest. Pretest average scores obtained were compared to an independent samples t-test. After the experimental process, the experimental and control group participants' physics laboratory attitude scale posttest average scores were also compared to an independent samples t-test. For each analysis, the effect size index which is eta-square (η^2) was calculated. The value of eta-square (η^2) being .01, .06 and .14 shows there is a small, medium or big influence respectively [3]. In the study, after the experimental process, semi-structured interviews about the virtual laboratory activities were carried out with 16 volunters participants from the experimental group. The qualitative data gathered from semi-structured interviews was submitted to a content analysis. In a content analysis, data that is similar, determined concepts and themes are compiled and analysed together [25]. The appropriacy of the coding in the study was reviewed by two experts (peer review). 9 out of 10 of the codes generated by the researcher were accepted by the experts. For the code which a consensus was not reached, the new code proposed by the researcher was accepted.

2.4 Research Design

In the study, an experimental research design including pretest and posttest control groups was used. In the research which the pretest-posttest control group experimental design was used, participants were randomly assigned to experimental and control groups. The research design is given in Table 1.

Table 1. Research Design

Groups	Pre Test	Application	Post test
Experimental	Physics Lab attitude scale	Virtual Lab	Physics Lab attitude scale Semi-structured interviews
Control	Physics Lab attitude scale	Physical Lab	Physics Lab attitude scale

2.5 Procedure

This study was conducted by carrying out a total of 5 experiments in physics lab course. One experiment was carried out per week. While the experiments in the experimental group were carried out via the virtual laboratory the control group conducted the same experiments in a physical laboratory environment. As the experimental group participants carried out the virtual laboratory activities on a computer in groups of threes, the control group participants used an experiment mechanism again in groups of threes. All lessons in both the experimental and control group were taught by the researcher.

Experiments in the experimental group were carried out using Circuit lab software. Experimental group participants were given the information on the virtual laboratory software prior to the experimental process. Circuit Lab is a software which enables students to easily to set up their own experiments and as well as designing different ones. In the software, equipment required for an experiment is chosen from the equipment menu and can be connected as desired on the display screen. The programme is ready to run with the help of the switch after the circuit installation is completed and the necessary measurement values are given by the circuit tools (Figure 1). Below is the list of experiments carried out throughout the study;

- Ohm's Law, parallel and serial connection of resistors,
- Kirchoff's Laws
- Charge/discharge of condenser
- Forces affecting conductive wire
- The magnetic field of a bobbin

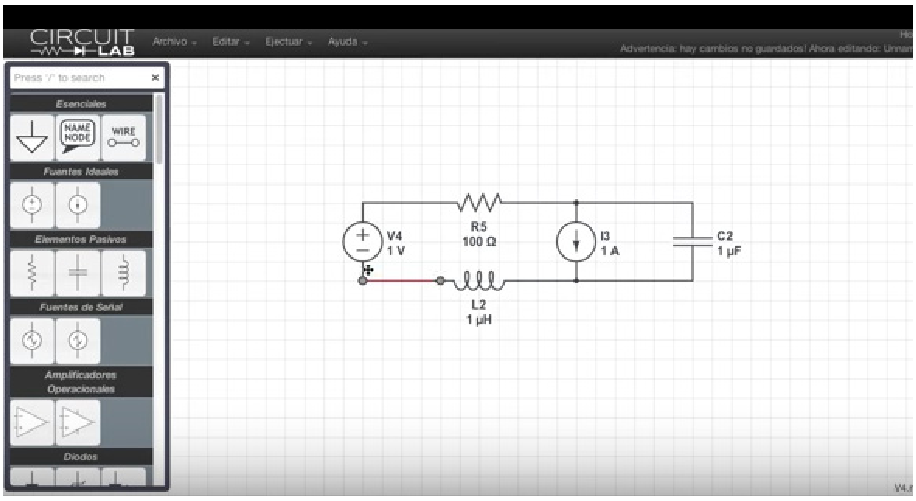

Fig. 1. The screenshot of a circuit created with the Circuit lab software

3 Results

In this section, the data analysis findings are presented under sub-headings according to the research questions;

3.1 The Effect of the Experimental Group Participants' Attitudes Towards the Course

In the study, before the experimental process, it was examined whether the experimental and control group participants had an equivalent attitude towards the physics lab course. For this purpose, the physics laboratory attitude scale was given to both groups as a pretest. The pretest average scores were also compared to an independent samples t-test. Table 2 illustrates the experimental and control groups' pretest average scores and their comparative analysis.

Table 2. Independent samples t-test results regarding pre-test scores of experimental and control groups

Groups	N	$\bar{X}$	S	sd	*t*	*p*
Experimental	21	93.04	21.67	4.728	3.781	0.237
Control	21	70.54	16.56	3.613		

Examining Table 2 shows that the experimental group's physics laboratory attitude scale pretest average is $\bar{X}$ =93.04, while the control group's is $\bar{X}$ =70.54. From the analysis results, it was determined that there isn't a meaningful statistical difference between the two groups' physics laboratory attitude scale averages ($t_{(40)}$= 3.781, p> 0.05). It can be said that prior to the experimental process the experimental and control groups' physics lab attitudes are equivalent.

At the end of the process (5 weeks later), in order to determine whether there was a meaningful difference between the experimental and control groups' attitude scores the physics laboratory attitude scale was used as a posttest and an independent samples t-test was applied to the results. The analysis findings obtained are illustrated in Table 3.

Table 3. Independent samples t-test results regarding post-test scores of experimental and control groups

Groups	N	$\bar{X}$	S	sd	*t*	*p*
Experimental	21	123.09	8.14	1.778	11.459	0.009
Control	21	74.49	17.64	3.851		

Examing Table 3 shows that the experimental group's physics laboratory attitude scale pretest average is $\bar{X}$ =123.09, while the control groups' is $\bar{X}$ =74.49. The analysis results show that there is a meaningful statistical difference between the two groups' physics laboratory attitude scale averages ($t_{(40)}$= 11.459, p> 0.05). In order to determine the impact of this difference in the experimental group's favour, the eta square value was calculated and found to be (η^2) 0.867. This value being bigger than 0.14 shows that the impact force is high. According to this finding, the experimental group participants' taking the physics lab course using the virtual laboratory activities attitudes were impacted more positively than the control group's participants'.

3.2 Participant Views on Virtual Laboratories

The study aimed to determine participants' views on the virtual laboratories in the physics lab course. The qualitative data, gathered from participant responses were examined under two separate themes: "positive" and "negative". Moreover, additional data was gathered on one or more codes under each theme from each student. The codes and frequencies under these two themes are presented in Table 4.

Table 4. Positive and Negative Participant Views on Virtual Laboratories

Theme	Codes	f
positive	The opportunity to reconduct experiments	15
	Conducting experiments quickly	13
	Designing new experiments	12
	Being enjoyable because conducted on a computer	10
	The opportunity to conduct experiments individually	8
	The opportunity to conduct experiments at the participants' own learning pace	6
	It eliminates interpretation and recording mistakes	6
	Fun	4
negative	Not being physical laboratory environment	2
	Difficult to use	1

In Table 4, it can be seen that a majority of the participants (f=15) declared being able to reconduct experiments as a positive aspect of virtual laboratories. Below are some examples of positive participant statements;

"When we used this software we gained time in the lab lesson. Setting up an experiment mechanism is time-consuming in a physical laboratory. Yet, it only takes us a few minutes on a computer to set up an experiment mechanism using the virtual laboratory. Thus, I could also design different experiments." (S11)

"I like conducting experiments alone. Because of the limited number of experiment sets in physical laboratories, 3 or more people have to work together on the same experiment. Using the virtual laboratory on my computer I was able to conduct experiments alone. Moreover, conducting experiments on the computer was more fun." (S8)

"We didn't only conduct that week's experiment. I would conduct other experiments after, I had finished that week's one. It was fun." (S7).

"I was able to conduct experiments on subjects that I couldn't understand over and over again. Plus, another advantage was changing the parameters and getting immediate feedback." (S14).

"While conducting experiments in physical laboratories having to record measuring and data at the same time led us to make mistakes. Whereas, with the virtual laboratory you cannot make mistakes while doing these." (S3)

In the interviews, a small number of participants stated that the virtual laboratories have negative aspects. Below are some examples of negative participant statements;

"I prefer doing experiments in a physical laboratory where I can touch the equipment." (S10)

"I couldn't focus on the experiments during the first week because I was spending my time trying to learn how to use the software." (S5)

Looking at participants' statements it can be said that the majority of students have a positive view on virtual laboratory activities.

4 Discussion and Conclusion

Because there are many abstract concepts in physics courses, students cannot visualise the events and thus have difficulty learning them. In order to change this perception about physics courses, it is necessary to make use of technology which concretizes abstract concepts. The aim of this study which examed the of impact virtual laboratories on physics education is to contribute to studies on the effect of rapidly developing information technology in physics education. Thus, the effect of using virtual laboratories in physics lab course and participants' views on this was explored.

At the end of the study, it was determined that the participants' views who engaged in the virtual physics laboratory activities showed a more positive increase than participants' using physical laboratories to conduct experiments. Furthermore, a majority of the participants have voiced positive a view on virtual laboratories. It is believed that this result stemmed from the simulations concretizing abstract subjects and enabling meaningful learning. In addition to this, it is thought that participants being able to conduct experiments at their own learning pace and the appeal of using computers also had a significant impact. Literature also has other research findings that declare virtual laboratories positively influence students' attitudes towards the course which overlaps with this study's findings. For example [11] state that using virtual laboratories in physics education increases student interest and provides a fun learning environment. [1], in his study, states that has teaching physics via interactive simulations a positive impact on students' academic achievement and their attitude. [2] state that virtual laboratories make learning physics concepts less complicated, and are effective in changing students' negative perceptions of the course. Similarly, [23], in his research states that virtual laboratories positively affect students' attitudes towards the course. [13] report that using virtual laboratories in science education has increased achievement and that students are satisfied using them to conduct experiments. Review of literature proves that there are other research findings that record virtual laboratories positively influence students' attitudes towards the course which overlaps with this study's findings.

When the study findings are evaluated in order to receive better results from using virtual laboratories in physics education, it is thought to be necessary that students are given enough time to conduct any experiment they like on their own and/ to design and conduct different experiments. Moreover, as virtual laboratories act as a bridge to comprehend the relationship between the subjects and real life events, it is believed that an appropriate teaching method and strategies should be used to pass on theoretical information.

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