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A MIXED APPROACH TO SOLVING PHYSICS PROBLEMS USING TRADITIONAL AND VIRTUAL LABORATORY WORK: A STUDY OF STUDENT PERCEPTIONS

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Abstract

In this paper we discuss the use of virtual experiments in traditional physics labs and their integration into the information and educational environment. It examines the implementation and use of existing software packages for virtual experiments. It formulates didactic approaches for managing knowledge acquisition through their combined application at all stages of the learning process—from knowledge updating to self-reflection in the classroom. The aim of the study is to analyze the use of virtual labs in the educational process of training physics students and the impact of virtual experiments on student performance in practical labs in a general physics course. This article presents an analysis of the use of virtual labs as a didactic tool that significantly expands the scope of students' independent, individual work, thereby facilitating the development of independent cognitive skills.

Keywords: Interactive laboratory work, virtual experiment, virtual laboratory work, laboratory practical training, hardware and software.

Introduction

The problem solving is an integral, inevitable, and inseparable part of science education. It also plays a central role in the teaching of physics, as physics is one of the core components of science education [1]. There are many definitions of problem solving. Some define it as a form of discovery learning that acts as a bridge between a student's prior knowledge and the solution to a problem. Others view it as a cognitive process aimed at achieving a goal when there is no obvious

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solution to a problem [2]. This develops students' critical thinking, which is necessary for decision-making skills. However, solving physics problems is truly a herculean task, as it involves abstract concepts that are difficult to implement. Therefore, visualizing the concepts requires constant experimentation, which reduces their abstractness. Consequently, when traditional laboratory work facilitates this, problem solving becomes easy. Such laboratory work not only helps students understand concepts but also enables them to define and explain laws and theories through hands-on activities [3]. However, these traditional laboratory activities are sometimes difficult to implement due to the lack of sufficient physical equipment, which is either very expensive or requires significant maintenance, making laboratory activities impractical and costly.

Thus, the need arises to find alternatives, and virtual laboratories are one such alternative. These labs possess remarkable features that make them unique, such as the safety of use without any time limits [4]. Their design allows students to complete a sufficient number of tasks to solve problems, which can vary in complexity. Furthermore, students can work both independently and in small groups, completing lab assignments, and receive immediate feedback from computer simulations.

Virtual laboratories play an unrivaled role in problem solving. However, these laboratories also have certain limitations, such as less face-to-face interaction. Therefore, there is a need to implement a combination of these two methods, both traditional and virtual laboratories, for solving physics problems. These improvements in the capabilities of both complement each other, thereby making their combination unbeatable. This combination, which takes into account both online activities and face-to-face learning, is called a blended learning approach [3]. Thus, students learn face-to-face in the classroom and simultaneously online outside the classroom. Therefore, students learn the content of physics problems in both traditional and virtual laboratories. Although the blended learning approach has been shown to be highly effective in improving academic performance, motivation, and scientific communication skills in physics courses [2], its practical value in solving physics problems has not yet been proven. More specifically, the role of the blended approach in solving problems through experiments in traditional and virtual laboratories, as well as the perception of

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this approach by senior high school students, remains to be studied, which is the subject of this study.

The photoelectric effect is one such concept, critical to understanding the corpuscular nature of light, a fundamental part of quantum mechanics.

The photoelectric effect is an important concept for helping students develop an understanding of the photon model of light and deepen their knowledge of it. Experience working with students over many years has shown that they experience significant difficulties in understanding even the most basic aspects of the photoelectric effect, such as the experimental setup, experimental results, and conclusions about the nature of light. A virtual laboratory on the photoelectric effect allows students to manipulate input data such as light, intensity, wavelength, and voltage, and receive immediate feedback on the results of changes in the experimental data. With proper guidance, students can use the virtual laboratory to create a mental model of a photoelectric effect experiment.

Selecting a virtual laboratory experiment

Designing a virtual laboratory experiment on the photoelectric effect can be a challenging task. There are websites that offer virtual laboratory experiments in various areas of physics. The researcher conducting this study explored this website and found a virtual laboratory experiment on the photoelectric effect that met the research goal and therefore decided to use it. This simulation allows students to control input parameters such as light intensity, wavelength, and voltage, and receive immediate feedback on the results of changes to the experimental setup. The phenomenon of electron emission by matter under the influence of light was called the photoelectric effect. Between 1888 and 1890, A.G. Stoletov conducted a systematic study of the photoelectric effect.

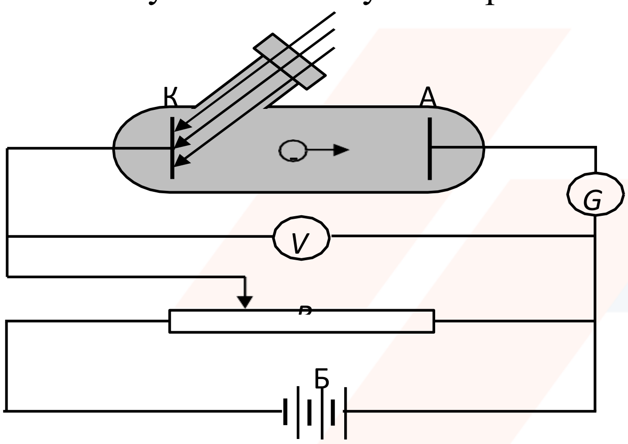

Fig. 1. Photoelectric effect study scheme

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The basic diagram for studying the photoelectric effect is shown in Fig. 1. Two electrodes in a vacuum tube are connected to a battery B so that, using a potentiometer R It is possible to vary not only the magnitude but also the sign of the voltage applied to the electrodes. The current generated when the cathode is illuminated with monochromatic light (through a quartz window) is measured by a galvanometer G connected to the circuit . With proper guidance, students can use the simulation to build a mental model of the experiment. This simulation also allows students to interactively plot graphs commonly found in texts and electron energy versus frequency. By looking at these graphs, students can see the relationships they see when viewing static images.

Research methodology

Third-year physics students were divided into two groups based on their grades from the previous year. Their performance was assessed using a pre-test with a performance test. Both groups were allowed to conduct the same experiment on the photoelectric effect. Participants in the first group, designated as the control group, were allowed to conduct experiments in a traditional laboratory setting. This group used traditional apparatus and materials for studying the photoelectric effect (e.g., a photocell, rheostat, power supply, ammeter, and voltmeter) in a conventional physics lab. Participants in the second group, designated as the experimental group, were provided with virtual laboratory capabilities to gain a conceptual understanding of the photoelectric effect. These participants used virtual apparatus and materials on a computer. A virtual laboratory environment was created for the study of the photoelectric effect experiment. Java was used for this purpose. Simulations . After completing the experiments in both situations, students in both groups were administered a "Performance Test" to assess their conceptual understanding of the photoelectric effect after the experiment, and their performance gains were calculated. In this study, the researcher compared the average achievements of each identified principle related to the "Exploring the Photoelectric Effect" experiment, which students completed in virtual and real laboratory settings. The following paragraphs, diagrams, and tables present comparisons of means, standard deviations, and t-values . A comparison of the pre- and post-test results of the experimental and control groups (the Physics Performance Test) is presented in Table 1.

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Table 1. Comparison of the results of preliminary and final testing of the experimental and control groups

Group	Number	Average	SD	t-value	df
Control	103	0.89	0.99	2.01	201
Experimental	105	1.20	0.98	2.21	206

Results and Discussion

As shown in Table 1, the average gains in the experimental and control groups were 1.20 and 0.89, respectively. Students in the experimental group who studied the photoelectric effect through a virtual experiment performed better than students in the control group who studied the same subject through a traditional experiment. Graph A below shows that the gains in student achievement in mastering each of the identified concepts in the "Exploring the Photoelectric Effect" experiment were higher through the virtual laboratory experiment than in the physical laboratory.

Analysis shows that the virtual laboratory experiment helps students better utilize each of the four concepts related to the photoelectric effect than the traditional physical experiment. The study found that the virtual laboratory experiment is more effective in developing concepts such as electromagnetic waves, frequency waves, potential difference, and current, as well as the nature of photons, in the area covered by the "Exploring the Photoelectric Effect" experiment, and the t value also confirms this. An independent t -test was used to further examine whether the difference in achievement gains between the two documents was truly significant. The results of the independent t -test clearly show a difference in the standardized achievement gain scores ($t = 2.21$, $p < 0.05$) in the experimental group. Therefore, it can be confidently concluded that the student learned the concept of the photoelectric effect better through the virtual lab compared to the traditional lab. This study demonstrated that the student learned the concept of the photoelectric effect better through the virtual lab compared to the traditional lab.

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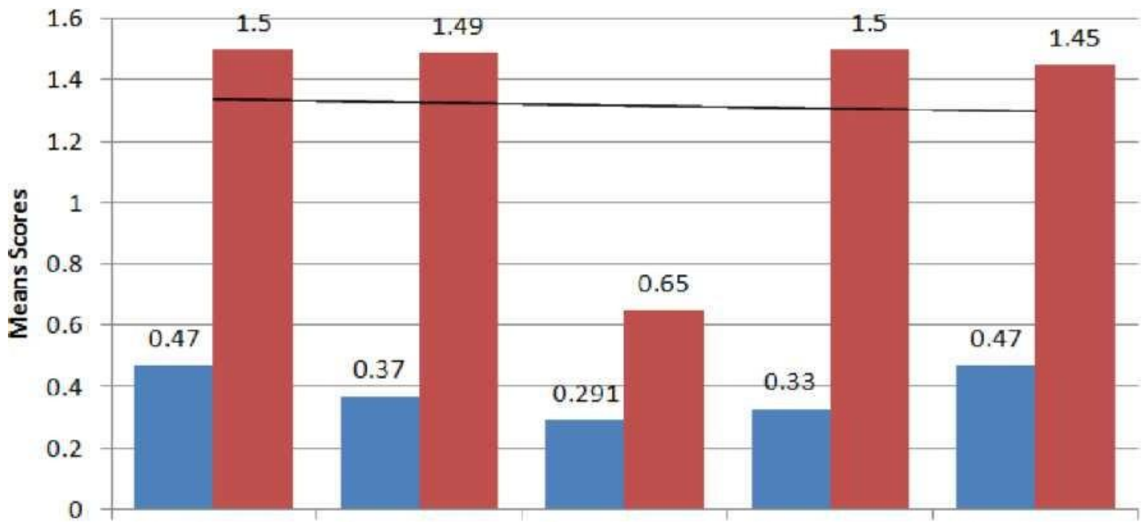

Fig. 2. Average performance scores of two groups studying concepts of experimental study of the photoelectric effect using virtual and traditional laboratory experiments.

Conclusions

According to the results of the study, it can be assumed that the use of a laboratory based on computer simulation, such as interactive physics, interactive simulation PheT, Crocodile Physics Edison 4.0 helped students grasp abstract concepts and thus improve student performance.

References

1. M.D. Aksenenko, M.L. Baranochnikov. Handbook "Optical Radiation Receivers", Moscow, Radio and Communications, 1987.
2. Diaghilev F.M. Quantum Mechanics. - M., Prosveshchenie, 1986.
3. L. N. Dobretsov, M. V. Gomoyunova. Emission electronics. — M., Nauka, 1966.
4. A.G. Berkovsky, V.A. Gavanin, I.N. Zaidel "Vacuum photoelectronic devices" - M., Radio and Communications, 1988.