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Effectiveness of Developing Concepts in Photo Electric Effect Through Virtual Lab Experiment

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Abstract: ***The ultimate goal of the authors is to examine the effectiveness of virtual labs as an instructional tool; and initial purpose here is to glean student perceptions of the tool from an evaluative perspective. In this way thepurpose of this study was to investigate the effect of Virtual Lab Experimentation (VLE) on students' conceptual understanding of photo electric effect. To achieve this, a pre–post comparison study design was used that involved 50 undergraduate students. Two groups were set up for this study. Participants in the control group used RLE to learn photo electric effect, whereas, participants in the experimental group used VLE. Achievement test was given to the groups before and after the application as pre-test and post test. The independent samples t- test, were used for testing the data obtained from the study. According to the results of analyzes, the experimental group was found more successful than the control group. It is hoped that findings from this study will provide useful information for instructional improvement as well as adding to the literature in this area***

Keywords: Computer Based Teaching, Java, Physics Education, Virtual Laboratory.

I. INTRODUCTION

Physics is one of the most fundamental natural sciences which are a field that involves the study of universal law and the behaviors and relationship among a wide range of physical concept and phenomena. Through the learning of physics student acquires conceptual knowledge relevant to their daily life and develop scientific attitude and vision. This scientific attitude and vision can be develop by allowing young minds to perform experiments in physics lab and observe and understand the scientific phenomena to happen in natural world in which we live. The process of reproducing phenomena in the laboratory enables scientists to study, in quantitative detail, aspects of specific phenomena, and to understand specific concepts. Lab plays very active and significant role for developing concepts in physics because students are continuously required to identify the hidden concepts, define adequate quantities and explain underlying laws and theories using high level reasoning skills (Nivalainen, Asikainen,) in these position students are involved in the process of constructing qualitative models that help them understand the relationships and differences among the concepts. Participation in these activities encourages students to bring scientific thinking to the processes of strong, innovative and logical path between concept and phenomena.

Although experiments are the hallmark of science, and for physics learning, they are essential to develop concepts and principles but traditional laboratory has some limitation and problems regarding to develop concepts. To examination of the related literature, laboratory education have not achieved its main goals, not provided meaningful learning, and not developed positive attitudes towards the developing concepts. As a result, today, more essential resources and time have been allocated in order to enhance the effectiveness of laboratories in physics teaching. In the study of Roth (1994) it was emphasized that the laboratory activities in science teaching were put into effect in the 1960s. However, students could not reach the desired levels by using these activities. Yager, Engen and Snider (1969) concluded that laboratory experiences are not meaningful adequately for students and therefore they do not make a significant contribution to their conceptual understanding. Renner (1986) emphasized that the importance of laboratory applications for science learning is agreed with everyone; however the actual role of the laboratories is not like this. According to Hofstein (1988), students were still performing experiments in the laboratory in a "cookbook" approach which focused on development of low level science skills

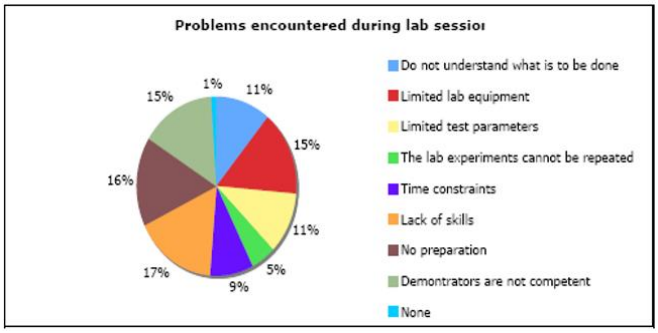

Figure 1: Results on related problems during lab sessions.

Zulkifli & Hassan(2009) studied problems during physics lab session. Above Figure-1 presents the results on problems encountered during the physical lab session. 17% of the students admitted on lack of skills in performing the experiments. Others agreed on lack of preparation (16%), limited lab equipment (15%) and incompetent lab demonstrators (15%). These factors may hinder them from successfully grasp the key concepts and knowledge expected from the experiments performed. In order to overcome these problems of physics instructor need to search a new philosophy in which learner are actively constructing their own knowledge (Jonget 1998) and instructor recognize student previous difficulty.

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With the availability of various ICT tools and techniques and their proper and synchronous use for various purposes, our perspective and approaches to teaching and learning of science particularly physics is also changing which is also making a paradigm shift in the whole environment. In present given scenario of ICT, virtual lab through computer simulation based method of teaching physics is emerging as one of the most powerful method of teaching. The experiments, traditionally conducted in physical labs, can now be performed on a computer.

"Virtual laboratory is a computer program that allows student to run simulated experiments via the web or as a stand-alone application". A virtual lab could be a set of simulations put together (Examples are applets, flash base demons, animations). This allows the students to perform the experiments remotely at any time. In addition, experimental-oriented problems can be conducted without the overheads incurred for maintaining a physical lab. A virtual lab is also particularly useful when some experiments may involve hazardous chemicals and risky equipment.

Virtual Lab also, is used in the system aiming to replace physical machine with virtual machines on one host server. They eliminate the limitation of physical appearance so that users are able to complete security exercises on the local operating system utilizing the client/server architecture.

The students could manipulate various parameters of the simulations and observed the result. In this approach there are certain advantage- It is very easy to learn how to use them, the leaning objectives is more clearly defined. Another approach to a virtual lab could be providing a virtual work place that obeys the laws of physics.

Research studies have indicated that visualization of phenomena through computer simulations can contribute to student's understanding of physics concepts at the molecular level by attaching mental images to these concepts (Cadmus, 1990). According to Escalada & Zollman (1997), computer simulations provide opportunities for students not only to develop their understanding and reinforcement of physics concepts, but also to develop their skills in scientific investigation and inquiry. Inquiry-based science experiences conducted in relevant, meaningful contexts have been shown to develop higher order thinking skill in students (Roth & Roychoudhury, 1993). This is further supported by Cakir and Tirez's (2006) study that found inquiry-based science teaching and learning, with the support of computer simulation and collaborative contexts help learners to develop critical thinking and inquiry skills. Lawson (1995) cites literature indicating that the Learning Cycle approach that consists of Exploration, Concept Introduction, and Concept Application phases is an inquiry-based teaching model which has proven effective at helping students construct concepts as well as develop more effective reasoning patterns.

Interactive learning environment by using simulations base virtual lab for abstract topic, where students become active in their learning, provide opportunities for students to construct and understand difficult concepts more easily (Demirci, 2003). In this content, appropriate simulations and applications based on simulations generally increase learning speed by allowing students to express their real reactions easily (Karamustafaoglu, Aydin and Ozmen, 2005). Better designed virtual labs provide students opportunities to express their cognitive style and to choose from the computer screen. Such opportunities allow students to develop their own hypothesis about the topic and develop their own problem solving methods (Windschitl ve Andre, 1998). According to Isman et al (2002), complex information given to the students is simplified by technology and provides them opportunities learning by doing. Therefore, use of virtual laboratory overcomes some of the problems faced in traditional laboratory applications and make positive contributions in reaching the objectives of an educational system.

Science educators have suggested that there are rich benefits that accrue from using lab experiment; mainly it's potential to understand the photoelectric effect. Photoelectric effect is a crucial step in understanding the particle nature of light, one of the foundations of quantum mechanics. The photoelectric effect is a powerful tool to help students build an understanding of the photon model of light, and to probe their understanding of the concept of photon model. However, research shows that students have serious difficulties understanding even the most basic aspects of the photoelectric effect, such as the experimental set-up, experimental results, and implications about the nature of light]. The virtual lab allows students to control inputs such as light intensity, wavelength, and voltage, and to receive immediate feedback on the results of changes to the experimental set-up. With proper guidance, students can use the virtual lab to construct a mental model of the experiment. Though the ultimate goal of the authors is to examine the effectiveness of virtual labs as an instructional tool, for conceptual understanding of physics .This study was designed in an attempt to contribute towards this direction by investigating whether the effect of virtual lab on undergraduate students' conceptual understanding of photo electric effect. Researchers suggested that developing conceptual understanding is only accomplished through learning that promotes conceptual change.Use of laboratory inquiry-based experimentation called Real Lab Experiment (RLE) and the use of virtual experimentation provided through interactive computer-based simulations called Virtual Lab Experimentation (VLE) could be used as conceptual change learning environments]. Real Experimentation has long played a vital role in science education.

A. Purpose

The main purpose of this study is to investigate the effectiveness of Virtual Lab for students' conceptual understanding of photo electric effect.

B. Objectives of the Study

1. To identify and design virtual lab situations from the available resources (Java Applets) with the help of which the above identified concepts and principles can be developed.
2. To Study the effectiveness of achievement of above identify concepts and principles through virtual lab vis- a vis real lab.

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C. Design of the Study

The effectiveness of virtual lab is studied through a pre–post comparison study *experimental design.* Experimental designs enable the production of the data to be observed under the control of the researcher in order to investigate cause and effect relations (Fraenkel & Wallen, 2003).

D. Sample of the study

Looking in to the nature of the study, Purposive sample was selected. The participants of the study were 50 undergraduate students (27 male, 23 female), ranging in age from 19 to 23 and taking "Physics Laboratory" class at Department of Physics of a College in Bhopal during the fourth semester of 2010-2011 academic year.

E. Procedure in Brief

50 undergraduate students studying in fourth semester of Graduation in science were divided in two groups based on their previous achievement marks in previous semester and their achievement was evaluated by administered Pre test through an Achievement Test". For both groups were allowed to perform the same experiment on photoelectric effect. The more detailed information about sampling is shown in the Table I below.

Table – I The Data About Sampling

		Gender		*N*
		M	F	
GROUP	*CONTROL*	*15*	*10*	*25*
	EXPERIMENTAL	*17*	*08*	*25*
	TOTAL	*32*	*18*	*50*

Group 1

Participants in the First group, designated as control group, were allowed to conduct experiment under real lab situations. This group used real apparatus and materials about "Photoelectric effect" (for example photocell, rheostat, power supply, ammeter, and voltmeter) in a conventional physics laboratory

Group 2

Participants in the second group, designated as experimental group the experimental group were provided the facilities of virtual lab for conceptual understanding of photo electric effect. These participants used virtual apparatus and material on a computer. For the study, a virtual laboratory atmosphere was created regarding "Experiment of Photoelectric Effect". To do that, it had been benefited from the Java Simulations. The Photoelectric Effect simulation, shown in Fig. 1, downloaded from the PhET website. This simulation allows students to control inputs such as light intensity, wavelength, and voltage, and it allows them to receive immediate feedback on the results of changes to the experimental set-up. With proper guidance, students can use the simulation to construct a mental model of the experiment. This simulation also allows students to interactively construct the graphs commonly found in textbooks, such as current vs. voltage, current vs. intensity, and electron energy vs. frequency. By seeing these graphs created in real time as they change the controls on the experiment, students are able to see the relationship between the graphs and the experiment more clearly than they see when viewing static images.

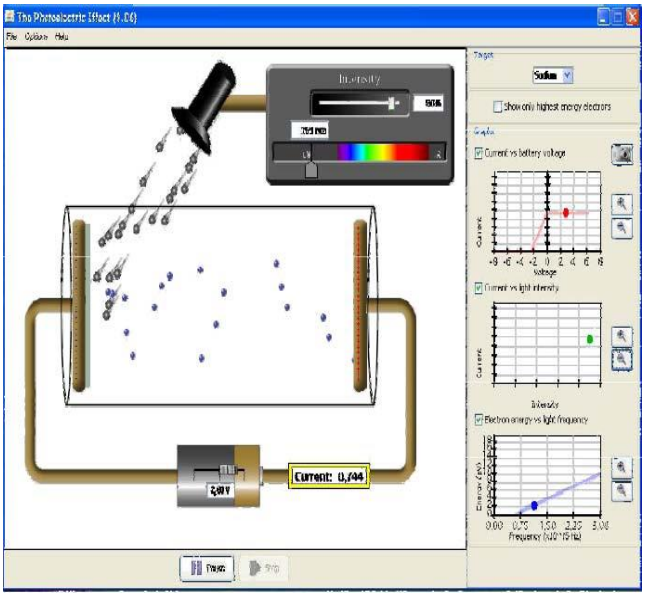

Fig. 2

After completing the experiments in both the situations, students of both the groups were administered Post "Achievement Test" to evaluate the conceptual understanding of photo electric effect after the experiment and achievement gains were calculated..

F. Statistical Analysis of Data

To study the effectiveness of virtual lab, the independent samples t- test, were used for testing the data obtained from the study. The SPSS 11.00 (Statistical Package for Social Sciences) statistical program was used to evaluate all the data collected from pre-and post-tests.

Findings

Statistical results about the comparison of pre-test and post-test scores of the experimental and the control group students in the PAT are given in Table 1.0

Table 1. 0 Statistical results of the comparison of gain scores of the experimental group and the in control group in the Achievement Test

Group	N	X (gain)	SD	df	t	p
Experimental	25	2	2.02	48	12.66	0.001*
Control	25	15	2.73			

II. RESULTS AND DISCUSSION

As given in Table 1, the mean gain of the Physics Achivement Test was X= 15.00 in the experimental group and gain scores of the experimental group in favor of post-test. While the mean gain scores in the control group was 02 between the arithmetic mean of these two gain in favor of post-test. Independent t-test was used to investigate whether the difference in Physics achievement according to the gain scores of the experimental group and the control group was significant and according to the independent t-test results, there is a significant difference between groups,

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scores of the Physics Achivement Test (t=12.66, p<0.05) in favor of experimental group.

The present study aims is to investigate the effectiveness of developing concepts in photo electric effect through virtual lab experiment which were designed according to computer-assisted and laboratory-assisted on student physics achievement. In the related literature, lots of studies were conducted to examine the effectiveness of computer simulation experiments and traditional experiments. Some researchers did not found any difference between their effectiveness (Miller, 1986; Choi Gennaro, 1987; Jimoyiannis & Komis, 2000; Şengel et al.,2002; Bayrak, Kanlı & Kandil, İngeç, 2007). On the other hand, according to the some researches, using computer technology in teaching implementations enhances the students' achievements in science education (Bennet, 1986; Güneş, 1991; Geban, Askar & Özkan, 1992; Svec & Anderson, 1995; Redish, Saul & Steinberg, 1997; Meyveci, 2005). Similarly, at the end of this study the significant difference is found between student achievements in physics in favor of the VLE. Consequently, to develop students' physics achievements, VLE can be more effective than the RLE. This result can be inferred from this research finding.

III. SUGGESTIONS

According to research results, it should be suggested using computer-simulation based virtual lab like interactive physics, Phet interactive simulation, Crocodile Physic, Edison 4.0 and Virtual Labs in physics laboratory to form simulations and animations of real-life situations, experiments and by this way to gain abstract concepts to the students and so to increase students' achievements. Moreover, using these programs is suggested by also other researchers (Şengel, Özden & Geban, 2002; Yiğit & Akdeniz, 2003; Görpeli, 2003; Bozkurt & Sarıkoç, 2008). In physics laboratory, imaginary experiments environments should be formed by using computers to prevent harmful effects of experiments and to represent the related concept or event. Also, due to the time consuming and being expensive, deficiency of lab equipment, teachers' anxiety about the completion of the curriculum as stated in the study of Kurt (2002), these virtual lab methods above should be used. To raise scientifically literate students, there should be strong relationship between science and technology. Teachers are the implementers of technology based curriculum. The problem here is that not awareness of teachers about technological devices, not using effectively these technological devices especially computers, not being volunteer using of them, not having experience about using technology, positive attitude towards technological devices and self-confident (Rohmer & Simonson, 1981; Okebukola, 1993; McInerney & Sinclair, 1994; Francis-Pelton & Pelton, 1996; Gökdaş, 2003). Therefore, it is suggested that teacher training about technology should be take into consideration by teacher training programs and these programs developers also.

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