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EFFECT OF VIRTUAL LABORATORY ON DEVELOPMENT OF CONCEPTS AND SKILLS IN PHYSICS

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Abstract-For physics learning, laboratory plays very active and significant role as it is essential to develop scientific processing skills. Students are continuously required to identify the hidden concepts, definition and explanation underlying laws and theories using high level reasoning skills. It is time and again observed that traditional real time physics laboratories have some limitations and problems in developing scientific processing skills. In the present given scenario of Information and Communication Technology (ICT), virtual laboratory through computer simulation based methods of teaching physics is emerging as on the most powerful method of experimentation in laboratory. The present study was conducted to see the effectiveness of virtual laboratory on Students' skills development in physics. In the study, 208 students of "+2" levels in science were selected. Purposive sampling techniques were used to select samples in two different groups (103-control group, 105-experimental group). The findings of the present study clearly revealed that students learnt concepts of photoelectric effect through virtual laboratory in a better way as compared to real laboratory. The study also suggested the use of virtual laboratory in physics teaching, visualization, graphical representation, especially for teaching of concepts in physics.
Keyword: - Physics Learning, ICT, Virtual Laboratory

1. INTRODUCTION

Physics is one of the most fundamental natural sciences which involve the study of universal law and the behaviors and relationship among a wide range of physical concepts and phenomena. Experiments are the hallmark of Physics. Scientific attitude and vision can be developed by allowing young minds to perform experiments in physics lab and observe and understand the scientific phenomena to happen. Learning through experiments encourages students to bring scientific thinking to the processes of strong, innovative and logical path between concept and phenomena. For physics learning, labs also plays very active and significant role as it is essential to develop science process skills because students are continuously required to identify the hidden concepts, define and explain underlying laws and theories using high level reasoning skills. Traditional laboratory has some limitation problems in developing these concepts etc. Today's traditional labs and the experiences acquired there, because of certain limitations of their own, are not meaningful adequately for students and are not able to make a significant contribution to conceptual understanding of students (Yager et al., 1969). According to Hofstein (1988), students are performing experiments in the laboratory in a "cookbook" approach which focused on development of low level science skills.
Zulkifli and Hassan (2009) studied problems during physics lab session. 17% of the students admitted on lack of skills in experiments. Others agreed on lack of preparation (16%), limited lab equipment (15%) and incompetent lab demonstrators (15%). These factors may hinder them from successfully grasping the key concepts and knowledge expected from the experiments performed. In order to overcome these problems of traditional physics lab, search of a new philosophy in which learner are actively constructing their own knowledge is needed present scenario virtual lab through computer simulation based method of teaching physics is an emerging powerful method of experimentation in lab. The experiments, traditionally conducted in physical labs, can now be performed on a computer through virtual lab.

2. VIRTUAL LAB

There are various ways of defining virtual lab. It can be defined as a computer program that allows student to run simulated experiments via the web or as a stand 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 students 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.

2.1 What Researches say about effectiveness of Virtual lab?

Although laboratory work is an indispensable element of understanding chemistry courses, previous studies have reported that it cannot be properly embedded into real physics lab for various reasons, such as safety concerns, a lack of self-confidence, and an excessive amount of time and effort required to conduct accurate experiments (Elton, 1983; Bryant and Edmunt, 1987; Hofstein and Lunetta, 2004; Durmus and Bayraktar, 2010). Nonetheless, it is not impossible to overcome these obstacles via technology-based alternatives (Okon et al., 2006). An alternative learning environment, called a virtual laboratory, can help to make this crucial
educational application available to students (Kumar Pakala et al., 1998; Shin et al., 2000; Grob, 2002; SAVVIS, 2010; Jeschke et al., 2010). Virtual laboratories simulate a real laboratory environment and processes, and are defined as learning environments in which students convert their theoretical knowledge into practical knowledge by conducting experiments (Woodfield, 2005). Virtual laboratories provide students with meaningful virtual experiences and present important concepts, principles, and processes. By means of virtual laboratories, students have the opportunity of repeating any incorrect experiment or to deepen the intended experiences. 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). 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 et al., 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 topics and develop their own problem solving methods (Windschitl ve Andre, 1998). Besides, students who are taught with laboratory-assisted education are more successful than students who are taught with traditional methods and also the learning with laboratory practices parallel with its theoretical knowledge in physics course increases the achievement. The laboratory applications also increase the permanence of students' knowledge. Some researches (Geban et al., 1992; Svec and Anderson, 1995; Redish et al., 1997) revealed that computer simulation experiments are more effective than traditional experiments: but some researches (Miller, 1986; Choi and Gennaro, 1987; Jimoyiannis and Komis, 2000; Bayrak et al., 2007) did not find any difference between their effectiveness. Therefore, no conclusions can be arrived at on the basis of previous researches hence some more researches are needed. The present study was conducted with this aim in mind. The main purpose of this study is to investigate the effectiveness of Virtual Lab on students' physics achievement.

2.2 Objectives of the Study

- To identify and design virtual lab situations from the available resources (Java Applets) with the help of which the above identified scientific processing skills can be developed.
- To Study the effectiveness of achievement of identify scientific processing skills through virtual lab compared to real lab.

2.3 Methodology of the Study

The present study employed pre- post experimental design. This experimental design enables the manipulations of the variables to be observed under the control of the researcher in order to investigate cause and effect relations. The variables under study are:

- Dependent Variable: Achievement Gains on photoelectric effect
- Independent Variable: Virtual and real laboratory Experiments on photoelectric effect
- Intervening Variable: Previous achievement in Physics

2.3.1 Identification and Significance of Topic

Physics is full of concepts and principles. During studies, a student is supposed to learn number of concepts. Researchers suggested that developing conceptual understanding is only accomplished through learning that promotes conceptual change and develop science process skills. Use of laboratory inquiry-based experimentation and virtual experimentation provided through interactive computer-based simulations could be used as conceptual change learning environments.

Photoelectric effect is one such concept crucial for understanding the particle nature of light, one of the foundations of quantum mechanics. The photoelectric effect is a significant concept which helps students builds an understanding of the photon model of light, and to probe their understanding of the concept of photon model. Experience of working with students during last so many years shows that they have serious difficulties in 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.

2.3.2 Selection of Virtual Lab Experiment

Development of Virtual Lab Experiment on the topic of Photoelectric Effect (PhET) can be time consuming task. There are web sites, where developed virtual lab experiments on different topics of physics are available .One such site is PhET website. The researcher of the present study has gone through this website and found a virtual lab experiment on photo electric effect fitting in to the purpose of the study and therefore, decided to employ the same. 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.

2.3.3 Sample of the study

Looking in to the nature of the study, Purposive sample was selected. The participants of the study were 208 (+2) students ranging in age from 16 to 20 and taking "Physics Laboratory" class at Govt.+2 High School, Patna City, Patna, Bihar during the 2nd year of 2011-13.

2.3.4 Tools employed

The present study employed following tools:

- Virtual Lab Experiment on the topic of Photoelectric Effect
- Pre and post achievement test on the topic of Photoelectric Effect
- Achievement of students in previous semester

2.3.5 Procedure in Brief

The step by step procedure of the followed in the present study can briefly be described as below:

- 208 (+2) students studying in 2nd year Intermediate in science were divided in two groups based on their previous achievement marks in previous year and their achievement was evaluated by administered Pretest through an Achievement Test". For both groups were allowed to perform the same experiment on photoelectric effect.
- 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.
- Participants in the second group, designated as 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.
- After completing the experiments in both the situations, students of both the groups was administered Post "Achievement Test" to evaluate the conceptual understanding of photo electric effect after the experiment and achievement gain was calculated.

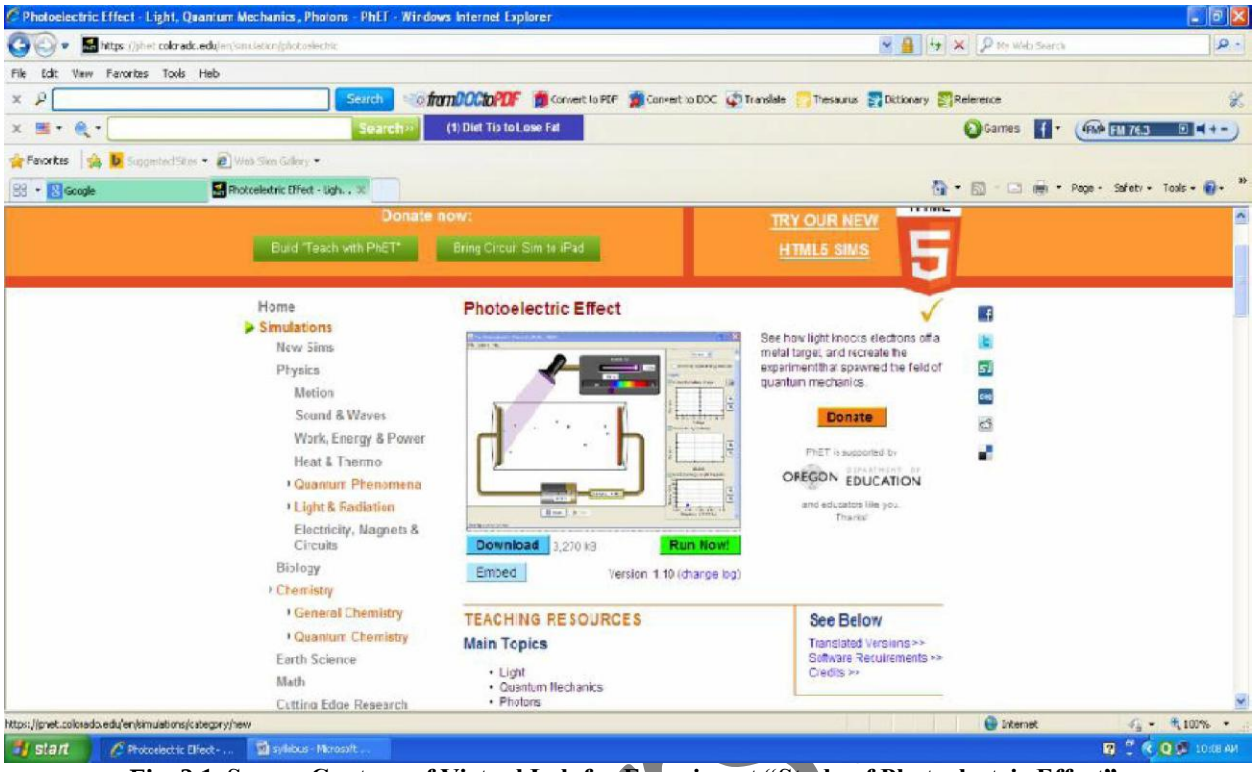


Fig. 2.1. Screen Capture of Virtual Lab for Experiment "Study of Photoelectric Effect"

- Statistical Analysis of Data

To study the effectiveness of virtual lab, the independent samples t- test, were used for testing the data obtained in 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.

3. FINDINGS

Ho-1.1There is no significant difference (at p = 0.05 level) between the control group and the experimental group in term of achievement gain of Photoelectric Effect

Under this the researcher isolated compared the mean achievement gains of each identified principles related to the experiment "Study of Photoelectric Effect" which are perform by the learner through virtual lab as well as real lab .Following paragraphs ,charts and tables show the comparisons of mean, standard deviations and 't' values with respect to above comparisons. These concepts are:-

- Electromagnetic waves
- Frequency of waves
- Threshold Frequency
- Potential difference and current
- Photon

Statistical results about the comparison of pre-test and post-test scores of the experimental and the control group students in the PAT (Physics Achievement Test) are given in Table 3.1.

Table-3.1Comparison of Achievement gain scores of students of the experimental group and control group

Group	N	Mean	SD	t-value	df
Control Group	103	0.89	0.99		
Experimental Group	105	1.20	0.98	2.21*	206

*Significant at 0.05 level

The Table-3.1shows that the't' value is more than the theoretical value. These indicate that the mean values of the two groups differ significantly at 0.05 level of significance.

Hence the null hypothesis "There is no significant difference (at p = 0.05 level) between the control group and the experimental group in term of achievement gain of Photoelectric Effect. "is rejected. Thus, it may conclude that the

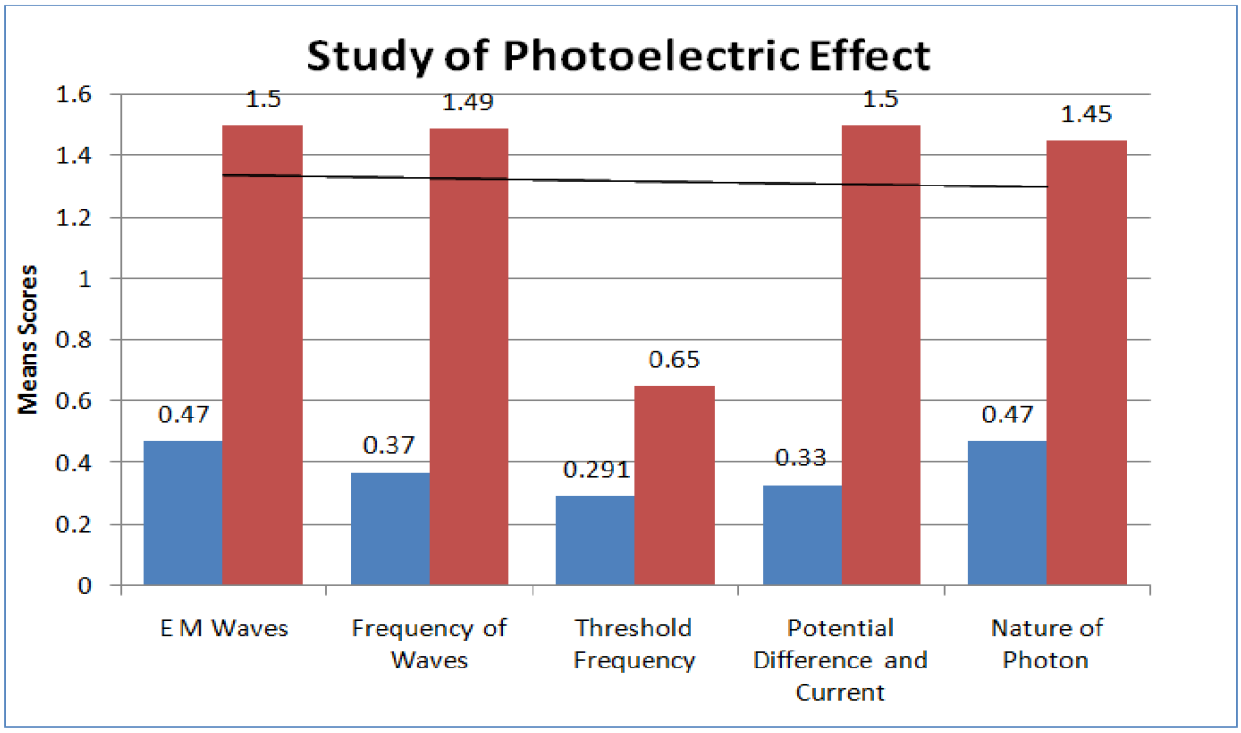
virtual lab experiment helps the student in developing principle of Photon and Energy better than the conventional lab experiment.

RESULTS AND DISCUSSION

As given in Table-3.1, the mean gain of the achievement in the experimental group and the control group was 1.20 and 0.89 respectively. Students in experimental group who learnt the concept of photoelectric effect through virtual experiment gained more compared to control group, who learnt the same through real experiment.

The below Graph-A shows that achievement gain of student in term of developing each identified concepts (excepted concept of Threshold frequency) of the experiment "Study of Photoelectric effect" through virtual lab experiment is higher compared to Real physics lab.

The analysis shows that virtual lab experiment helps the student in develop each four concepts related to the Photoelectric effect in better way than the real physics lab experiment. The study found that virtual lab experiment is more effective for development of concepts i.e. electromagnetic waves, frequency of wave, potential difference and current and nature of photons related to the experiment "Study of Photoelectric effect" and 't' value also prove the same. Independent t-test was employed to investigate further whether this difference in achievement gains between two groups is really significant .Independent t-test results, clearly shows that there is a significant difference between groups, scores of the achievement gain ($t=2.21$, $p<0.05$) is in favor of experimental group. Therefore, it can safely be concluded that student learnt concepts of photoelectric effect through virtual lab in a better way compared to real lab. The present study found that student learned concepts of photoelectric effect through virtual lab in a better way compared to real lab. The findings of the study corroborates with the findings of earlier studies such as (Bennet, 1986; Güneº, 1991; Geban et al., 1992; Svec and Anderson, 1995; Redish et al., 1997; Meyveci, 2005). However contradicts with that of (Miller, 1986; Choi Gennaro, 1987; Jimoyiannis and Komis, 2000; Þengel et al., 2002; Bayrak et al., 2007). The contradictions in findings of these studies with the present one may be due the nature of concept to be learned, approach of virtual lab design, control of intervening variable, different design of the study and statistical analysis etc. Therefore, some more such researches are needed to arrive at valid generalization.



Graph-A The mean Achievement Gain scores of Two Group's of Developing Concepts of Experiment Study of Photoelectric Effect, Through Virtual Lab Experiment and Real Lab Experiment

SUGGESTIONS

- According to research results, it may be suggested that using computer-simulation based virtual lab like interactive physics, PheT interactive simulation, Crocodile Physics, Edison 4.0 helped students to gain abstract concepts and so to increase students' achievements.

- Moreover, use of these programs is suggested by also other researchers (Þengel et al., 2002; Yiðit and Akdeniz, 2003; Görpeli, 2003; Bozkurt and Sarýkoç, 2008).
- In view of time consuming and being expensive, deficiency of physics lab equipment, teachers' anxiety about the completion of the curriculum as stated in the study of Kurt (2002), these virtual lab methods as stated above should be used.
- 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.
- Teachers are the implementers of technology based curriculum. Teachers should be given training from time to time to make them aware about technological devices, effective use of these technological devices especially computers, creating volunteerism in using them, developing positive attitude towards technological devices and self-confident (Rohmer and Simonson, 1981; Okebukola, 1993; McInerney and Sinclair, 1994; Francis-Pelton and Pelton, 1996; Gökdaº, 2003).

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