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Effectiveness of Physics Education Technology (PhET) Interactive Simulations in Teaching Physical Science

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Abstract: ***The study aimed to determine the effectiveness of Physics Education Technology (PhET) interactive simulation in teaching Physical Science. Two heterogeneous sections in which each section is composed of 30 students were the participants of the study. It was conducted at Albor National High School-Albor, Libjo, Dinagat Islands.The group assigned as experimental group used the PhET Interactive Simulation in conducting the experiments whereas the other group utilized the conventional method with real laboratory apparatus in conducting experiments. Lesson logs were used as a guide in discussing and conducting classes on both groups. A 50-item multiple choice pen and paper test about selected topics in Physical Science was administered as pre-test and post-test for both groups. The data were statistically analysed using the frequency count and percentage, mean and standard deviation t-test for dependent means and ANCOVA. The study showed that the average score in the pre-test of the students from control group and experimental group were 67% and described as did not meet expectation. However, the average score in the post-test of the two groups both described as fairly satisfactory. There was a significant increase on the mean scores of the students in control and experimental group between the pre-test and post-test. But, there was no significant difference on the post-test scores between the experimental and control group because the academic performance of the students in two groups had increase.It can be deduced that the students in both groups have the capacity to learn concepts in Physical Science. Also, the conventional method with real laboratory apparatus and PhETInteractive Simulation are both effective approaches in teaching Physical Science lessons since the academic performance of the students significantly increase from pre-test to post-test. Therefore, PhET Interactive Simulation can be used as instructional materials in conducting experiments in lieu of the real laboratory apparatus.***

Keywords: PhET Interactive Simulation, Physical Science

1. Introduction

Physics Education Technology (PhET) simulations target specific student learning difficulties and learning goals in science education. The simulations aim to engage students in scientific exploration and to increase student interest in science, thus, PhET simulations are designed to be fun and interactive, to connect to the real world, to provide multiple representations, and to allow rapid inquiry cycles (Lancaster, Moore, Parson and Perkins, 2013).In addition, Perkins,Moore, and Chasteen (2015)found out on their survey conducted online that teachers use PhET in multiple ways for a variety of learning goals, indicating that the flexible nature of PhET simulations contributes to its usefulness.

Moreover, it has been emphasized today to utilize resources online due to lack of concrete instructional materials.DepEd Order No. 76, s. 2011 mandates the National Adoption and Implementation of the Learning Resource Management and Development System (LRMDS) wherein teachers will make use of available materials in the internet in teaching the lesson. Adopting readily accessible materials from the internet is of great importance especially if real laboratory apparatus and instructional materials are inaccessible.

Zengele and Alemayehu (2016) opined that the most determinant constraints of laboratory activities in secondary schools of Wolaita Zone, Southern Ethiopia include lack of laboratory rooms, inadequate supply of laboratory equipment, reagents and facilities and absence of trained laboratory technicians/teachers. Likewise, The Manila Times on Science Education Realities (Manila Times, 2014) pointed out that the Department of Education reports a serious lack of science laboratories in both elementary and high schools in the Philippines. Clearly, laboratory activities will not be carried out due to lack of science laboratories and insufficiency of laboratory apparatuses.

Albor National High School-Albor, Libjo, Dinagat Islands has no well-lighted and ventilated science laboratory room and has an incomplete science laboratory apparatuses. It has been a problem in the school whenever there are lessons that need experimentation and laboratory activities. Due to the unavailability of the laboratory apparatuses, the teacher will resort to teaching the topics using a lecture method instead of employing the discovery approach. Aside from this, the senior high schools students of the same school were performing low in Science subject. This is evident on the item analysis result of the students in science subject based on the record of the science teachers in the aforementioned school.

These premises prompted the researcher to conduct a study on the effectiveness of PhET Interactive Simulations in teaching Physical Science lessons. The simulations serve as instructional materials in conducting experiments in lieu of real laboratory apparatuses and also to improve the academic performance of the students in Science.

2. Materials and Methods

The researcher used quantitative research design specifically the Quasi-Experimental method was employed. The study was conducted in Albor National High School, Albor, Libjo, Dinagat Islands. The participants of the study were the Grade 12 students in the aforementioned schoolspecifically sections Neon and Helium. Both sections were composed of

students enrolled in SMAW, ABM and HUMSs strands from the TVL and academic tracks for the S.Y. 2018 – 2019.

Figure 2: Research Locale

This study utilized Pretest and Posttest questionnaires and lesson logs. The Pre-test and Post-test questionnaires made by the researcher was consist of fifty (50) item-multiple choice questions. Lesson logs were content validated by panel of experts and pre-test and post-test questionnaires were presented first to the adviser. It was reliability tested using a Cronbach alpha correlation which is 0.891, hence it is highly reliable.

The researcher wrote a formal letter of request to the Secondary School Principal of Albor National High School. Furthermore, the researcher asked permission and consent from the parents and students before the conduct of the study to avoid any nuisance while conducting the study.

The researcher downloaded the PhET Interactive Simulation applications that were applicable in the chosen topics in Physical Science subject at www.PhETColorado.edu.ph. website. The availability of the PhET Interactive Simulation and as well as the materials needed by the control group in conducting the experiments was considered in choosing the topics to be included in the study.

Upon approval, the researcher conducted the study using the developed lesson logs of PhET Interactive Simulation approach and Conventional method. Before conducting the lessons on experimental and control groups, a pre-test was administered that lasted for one (1) hour.

Afterwards, the researcher delivered the lessons on both groups that lasted for 1 month lecture and discussion. Both groups were discussed with the same process but they only differ on the materials used in conducting the experiments since the experimental utilized the PhET Simulation while the control group used the real laboratory materials. After all the lessons were discussed, a post-test was administered to both groups-experimental and control group. The scores of the learners was tallied and recorded. Then it was treated by the statistician. Once treated, it was analyzed and interpreted to determine the effectiveness of the Interactive Simulation in teaching Physical Science lessons.

3. Results and Discussions

On the Average Score in the Pre-test and Post-test of the Control and Experimental group

Table 2 presents the average scores derived from the pre-test and post-test in the control and experimental group.

Table 2: Control and Experimental Group Average Scores in the Pre-test and Post-test

Test	Group	Mean	SD	Percent	T	Description
Pretest	Control	14.77	2.94	29.53	67	Did not Meet Expectation
	Experimental	14.27	3.81	28.53	67	Did not Meet Expectation
Posttest	Control	30.03	8.60	60.07	75	Fairly Satisfactory
	Experimental	31.27	7.54	62.53	76	Fairly Satisfactory

Legend: T - Transmutation (Based on DepEd Table)

As reflected in the table, the control group got an average score of 14.77 in the pre-test equivalent to a transmuted grade of 67% described as **did not meet expectation.** The standard deviation of 2.94 showed that the scores of the students were closer and not spread. Thus, majority of the students got a lower score.Their scores increasedin post-test to 30.03 and equivalent to a transmuted grade of 75% quantitatively described as **fairly satisfactory**. It can be inferred that the improvement of the students in the control group is evident and enough to pass the test. Most likely, conventional approach using the real laboratory apparatus is effective in improving the academic performance of the students. However, the scores of the students in the post-test are quite spread since the standard deviation is high. It means that some of the students got a higher score but others still got very low scores.

This result coincided with the study of Kimiti,Mulinge, and Muriungi (2017), they found out thatthere is significant relationship between laboratory facilities and the students' academic performance in science subjects, and teachers used of laboratory facilities in teaching science subjects had significant effect on students' performance in science subjects. Thus, the conventional method using real laboratory apparatus can improve the academic performance of the students in Science subject.

Considering the experimental group, the students got an average score of 14. 27 in the pre-test equivalent to a grade of 67% described as **did not meet expectation**. Examining the standard deviation in the pre-test, the scores in the experimental group were spread than the control group. Although majority of them got a low scores but some of the students got very low scores than the other. In their post-test, the students' average score increased to 31.27 equivalents to a grade of 76% described as **fairly satisfactory**. Also the standard deviation is smaller than the control group, this signify that there scores were closer and majority of the students got a passing scores. Results showed that PhET Interactive Simulation is effective in improving the academic performance of the students.

Adams et al., (2010) said that there is considerable evidence that PhET interactive simulations can be powerful tools for achieving student learning of science. Based from the survey of Pulido, Bandoy and Sauquillo (2015), they found out that majority of the respondents agreed that PhET helped them learned the concepts, improve their problem solving skills, building confidence to lessen their fears in Physics, developing self-reliance and improving test scores.

Josephsen and Kristensen (2006) opined that the students found the Simulation Laboratory motivating and creating attention towards the practical application of declarative knowledge. They also found SimuLab to support students in the accomplishment of cognitive tasks and to enhance their skills in the context of the investigation.

However, the low average scores in the pre-test of control group and experimental group showed that students from two groups had little background knowledge about the chosen topics in Physical Science and also the students from the two groups had equal abilities in academic since their average scores were almost the same. HailikariKatajavuori and Lindblom-Ylanne (2013) pointed out that prior knowledge has long been considered as the most important factor influencing learning and student achievement. The amount and quality of prior knowledge influence both knowledge acquisition and the capacity to apply higher-order cognitive problem-solving skills.

On the significant increase on the mean scores of the Control and Experimental group between the Pre-test and Post-test

Paired sample T-test was used to determine if there is really improvement of the scores of control and experimental group between the pre-test and post-test. The results were presented at Table 3.

Table 3: Pre-test and Post-test Significant Difference in two Groups

Group	Test	Mean Difference	95% Confidence Interval		t (d=29)	P	Decision
			Lower	Upper			
Control	Pre-test Posttest	15.3	12.21	18.32	10.21	4.13E-11	Rejected
Experimental	Pre-test Posttest	17.0	14.66	19.34	14.88	4.15E-15	Rejected

It can be observed from the results in the control group which obtained t statistic 10.21 with a p-value 4.13E-11 that is less than 0.05 level of significance; hence, the null hypothesis is rejected. This signifies that there is significant difference in the scores of the students between the pre-test and post-test of the control group. It signifies that the conventional method with real laboratory apparatus can improve the academic performance of the students. It really improved the marks, on average of 15.3 points. The increase is quite high; therefore, the approach is commendable to be used in teaching science concepts. It was found out in the study of Ihejiamaizu and Ochui (2016) that the utilization of Biology laboratory equipment significantly influenced students' academic performance in Biology.

Moreover, analyzing the results in the experimental group, the computed t-statistics is 14.88 and got a p-value of 4.14E-15 which leads to the rejection of the null hypothesis, thus, there is significant difference between the pre-test score and post-test score of the students in experimental group. This signifies that the PhET Interactive Simulation as a material in conducting experiments is also effective in improving the performance of the students in Science. Considering the mean difference, it shows that the scores improved by approximately 17.0. The increment is quite large, thus, the simulation can sufficiently improve the academic performance of the students. Batuyong and Antonio (2018) found out that there is a significant improvement of the physics academic performance of the students when taught using the developed PhET Interactive Simulation based Activities.

Generally, the foregoing results showed that the conventional method with the use of real laboratory apparatus and the PhET Interactive Simulation are effective improving the academic performance of the students in Physical Science both TVL and Academic track students.

On the Significant Difference on the Post-test scores between the Control and Experimental Groups

Table 4: Significant Difference between the Control and Experimental Group Scores in Post-test

Groups	df1	df2	F	p	Decision
Control vs Experimental	1	2.00	0.845	0.362	Not Rejected

Analysis of Covariance (ANCOVA) was used to determine the significant difference between the control and the experimental group in the post-test after controlling the effect of pre-test.

Based on Table 4, the computed F-statistic is 0.845 and has a p-value of 0.362. Since the p-value is greater than 0.05 level of significance, the null hypothesis is not rejected. This

implies that in the post-test, there is no significant difference in the academic performance of the students in control and experimental group. It signifies that the conventional method with the use of real laboratory apparatus can significantly increase the academic performance of the students and also the PhET Interactive Simulation. Although, there is no significant difference between the two approaches but the scores in the experimental group were closed to each other which means that majority of them got passing scores.

In addition, it implied that the use of PhET Interactive Simulation is as effective as the real laboratory apparatus in increasing the academic performance of the students in Physical Science. Therefore, PhET Interactive Simulation can be used as instructional materials in conducting science experiments and activities in lieu of the real laboratory apparatuses.

The result agreed with the study of Tatli and Ayas (2010) as cited by Omilani, Ochanya and Amino (2016) that virtual laboratory is at least as effective as the real laboratories both in terms of students' achievement and their ability to recognize laboratory apparatus. Hawkins and Phelps (2013) added that there is no significant differences in scores on either the pre-test and post-test on the experimental group exposed to a virtual laboratory and control group exposed to a normal hands-on laboratory.

Furthermore, Bayrak, Kanlı and KandilİngeÇ (2007)as cited by Gamabri and Falode (2012) did not find any difference between the performance of students taught with virtual laboratory and those taught with traditional laboratory method. It was concluded that the developed virtual chemistry laboratory software is at least as effective as the real laboratory, both in terms of student achievement in the unit and students' ability to recognize laboratory equipment (Tatli&Ayas, 2013).

4. Conclusion

The students in SMAW, ABM and HUMSs strands have the capacity to learn concepts in Physical Science. Conventional method with the use of real laboratory apparatus and PhET Interactive Simulation are both effective approaches in Teaching Physical Science in order to increase the academic performance of the students in ABM, HUMSs and SMAW Strands. The PhET Interactive Simulations can be used as instructional materials in conducting experiments and laboratory activities in lieu of the real laboratory apparatuses to employ discovery approach.

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