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The Effects of Using Virtual Laboratory Materials on Students' Academic Performance in Physics

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Abstract- Physics teaching is not only limited unto imparting theories and facts about various physical discoveries. To effectively teach physics, a physics teacher must allow students to have a hands-on activity on the concepts for them to attain maximum learning. However, many high school laboratories today have scarcity on different laboratory apparatuses which become a major problem to many physics teachers. The study investigated the effects of using virtual laboratories on the academic achievement level of grade 10 students of Zamboanga Del Sur National High School in Physics during the S.Y. 2015-2016. The study uses quasi-experimental, static group, pretest, and posttest design. Two intact classes were used in the study out from 55 students in the control group 30 were match with the other 30 from 52 students in the experimental group. A researcher-made achievement test was administered to both groups as pretest and posttest to determine the academic performance of students in physics. The result was subjected to statistical analysis like descriptive statistics, as well as ANCOVA to know which treatment yield a favorable result to the academic performance of the students in physics. A higher marginal mean in the posttest and pretest of the experimental group were observed compared to the control group. Furthermore, the academic performance of the experimental and control group significantly differ statistically. This proves that the application of virtual laboratories to students is effective in increasing their academic performance in physics.

Keywords- *Virtual Laboratory Activity, Real Laboratory Activity, Academic Achievement Level, Quasi-Experimental Design, Pretest, Posttest*

I. INTRODUCTION

For a long time, Physics teaching in our country was conducted mostly without experimental bases. It simply implies that Physics instruction almost entirely was and still in many places today is carried out by lecturing and plain problem-solving procedures on the board. Because of this unsatisfactory quality of teaching, like that of the explanatory and display teaching, we see why many students in the Philippines show very little desire and motivation in learning Physics.

Physics teaching is not only limited unto imparting theories and facts about various physical discoveries. To effectively teach physics, a physics teacher must allow students to have a hands-on activity on the concepts for them to attain maximum learning. John Dewey (1933) became very famous of his learning by doing concept stating that student will learn much if they will be exposed to hands-on activities where in their manipulative skills of the different variables in science experiments will be engaged in the learning process.

Lkhagva Oidov, Ulambayar Tortogtokh, & Enkhtsetseg Purevdagva (2012) created a virtual laboratory for physics training for general secondary schools in Mongolia. These virtual laboratories become the manipulative base for learners in studying the various physical phenomenon in learning and teaching Physics. In the construction of models for physical processes and laws, programming tools such as object-oriented Delphi, C++, Java, C# and OpenGL graphics library are used. The investigation shows that conducting laboratory activities using the software program make students become able to perform numerical measurements and get computer estimations of physical quantities. This could lead students to collaboratively discuss and debate on the collected data results making them interpret and deduce physical quantities into a formula and make use of it in understanding concepts in physical laws and regularities. This makes the learners discover physical laws themselves.

Colm O'SULLIVAN (2004) on his study concluded that a remarkable advantage may be obtained by integrating ICT in science and technology education. It further contest that "real" laboratory experiments aided with the utilization of data acquisition systems can be useful in the classroom plus the use of "virtual" laboratories with interactive simulations and animation could provide an opportunity for a deeper level of integration of ICT based material to the learners leading to in depth understanding of physics concepts.

J. Jorge, J.M. Mercadé, L. Conangla, & E. Ferreres (2007) concluded on their research on making a Virtual Learning Environment for Non-Assisted Physics Laboratory have found out from a survey that students urge virtual engineers to develop more Virtual Learning Environment Programs to improve their autonomous learning skills in learning physics subjects.

The Zamboanga del Sur National High School under the City Schools Division of Pagadian City is one of the leading schools in the entire Zamboanga Peninsula. However, even how big the school is, facilities are still scarce. It can be noticed just like any other high schools in the division, that teachers resort into using improvised apparatus just to show

students the effects of the interactions of several physical variables. However, since the improvised apparatus was just made up of indigenous materials it cannot really guarantee accurate data results in the different experimentation.

Laboratory In-charge of the Zamboanga del Sur National High School attests that the apparatus present in the laboratory were really limited that only very few competencies in physics lessons have available apparatus for experimentation and if there's any it could either be defective or damage. Moreover, Physics teachers testify that even available apparatus are obsolete and cannot even give accurate results during the experimentation.

In this regard, the school needs to have an alternative solution to the problem on lack of laboratory equipment and apparatuses and the solution would be to use virtual laboratories that would yield the same laboratory conditions to real laboratories as well as producing competent data results. This eventually develops student's science process skills that prepare them into becoming aware of the real-life situations.

A. The basis for the Conduct of the Study.

1) Laboratory Apparatuses and Equipment

Available in the ZSNHS-Physics Laboratory of the Zamboanga del Sur National High School was not really reliable for experimentation of various physics competencies. The available laboratory apparatuses are either lacking or defective. In addition, the 24 sections in the grade 10 curriculum with at least 50 students in each section could really find hard using the apparatuses in the various physics experimentation due to insufficiency of functional apparatuses. Physics teacher testifies that instead of relying on the available apparatus in the laboratory for activities and experiments, they resort into using video presentations wherein students will just have to watch the animations in the video as to how these physical phenomena are exhibited in the natural environment.

Lkhagva Oidov, Ulambayar Tortogtokh & Enkhtsetseg Purevdagva (2012) has concluded in their investigation that the disadvantage of just showing video animations about physical phenomena would prevent students of developing the skill and ability to manipulate laboratory instruments. This would then imply low performance and retention of concepts compared to activities that have hands-on manipulations of the variables in which virtual laboratories can provide. Moreover, it was also evident that some available apparatuses are defective and cannot produce accurate data result in different physical activities.

2) Teachers capability to utilize virtual laboratory

Out of the 6 physics teachers the Zamboanga del Sur National High School, only one does not have a personal laptop computer readily available for physics instruction. This implies that almost 83% of the population of physics teachers in the institution has the full capacity to utilize their personal computers for instructional purposes by using virtual laboratory programs in their physics classrooms. However, 3 teachers profess that they need to undergo training on how to use these virtual laboratories because these were new to them and they do not know how to manipulate the virtual learning package themselves.

3) Academic achievement of students in physics during SY 2015-2016

With these observed variables: (1) Long Quiz, (2) Laboratory Grades, and (3) Final Average Grade. Descriptive Statistics of the Performance of Students during SY 2015-2016 in terms of their Long Quiz Grades, Laboratory Grades and Final Average Grades in Physics revealed that the students perform poorly on their laboratory activities and perform both satisfactorily on their long quiz and in the final grade. Their long quiz and final average grade obtained a low standard deviation (2.58 and 1.83 respectively) which implies that their grades in the long quiz and in the final average grades were not dispersed and therefore very close with each other. The high standard deviation (11.44) of the student's laboratory grade could mean high dispersion on their grades which might be due to learners' confusion on the concepts which resulted to failed experimentation due to defective apparatuses.

4) Correlation Analysis on the Grades of Physics Students in their Laboratory Activities, and Final Average Grades

It shows that laboratory activity grades have a moderate correlation to the long quiz grades (0.40) and has high correlation on the final average grades (0.7) of students in physics. This implies that laboratory activities play a vital role in the performances of students both in their long quiz as well as in their final average grade in physics. These findings lead to a consideration that activities are done by students would give much impact to their learning on the specific concepts in physics.

Furthermore, this also implies that students should use accurate laboratory instrument that would yield accurate results because if they use inaccurate defective apparatuses it could lead them to learn inaccurate information. These findings corroborate with the investigation done by Lkhagva Oidov, Ulambayar Tortogtokh & Enkhtsetseg Purevdagva (2012) that as virtual laboratories help learners process and interpret physics data (information/facts) if they were not exposed to virtual laboratories they yield poor results in their various evaluations and tests. In addition, students become able to write out formulas and formulate fundamental laws of physics themselves due to utilizing accurate laboratory activities with the aid of either real laboratory activity or virtual laboratory activities.

5) Regression Analysis on the contribution of the student's laboratory grades to the student's long quiz and final average grade in physics

The results have shown that laboratory activity grade is really an active factor that significantly affects the academic performance of students in physics. It is also evident from the results that Laboratory activity grades greatly contribute to the final average grade (48.4%) compared to its contribution to the long quiz (15.8%). This implies that laboratory activity contributes to the overall performance of the students in learning physics concepts. In line with this findings, the conclusion of Slavko Kocijancic & Colm O'Sollivan (2004) states that it doesn't matter if which is better the use of real laboratory or virtual laboratory, the two approaches could contribute effectively in the learning process.

This study investigated the effect of utilizing virtual laboratory material in replacement of the normal laboratory activities performed in actual, real laboratory on students' academic performance. Specifically, this research aimed to answer the following questions: (1) What is the level of performance of grade 10 students in physics applied with real laboratory activities and students applied with virtual laboratory activities in their pretest and posttest; and (2) Is there a significant difference between the academic performance of the students applied with virtual laboratory activities and students applied with the real laboratory activities?

The study may help physics teachers improve their teaching styles and increase their teaching performance, which eventually also give much impact to the overall performance in the National Achievement Test results increasing the mean percentage score of the students in science. Moreover, the result of this investigation would somehow serve as raw information for other investigators and researchers conducting research on studies similar to this. Furthermore, this investigation could widen our perspective on pursuing new avenues for investigation and research in the field of teaching and education.

II. MATERIALS AND METHODS

This study was conducted in the Zamboanga del Sur National High School, Pagadian City, under the City Schools Division of Pagadian City, Region IX from February 2016 to March 2016 under the fourth quarter of the school year 2015-2016. A quasi-experimental research design was used in this investigation. This involved the test of the effectiveness of the use of virtual laboratories in physics lesson using the non-equivalence static group comparison pre-test post-test design.

Participants of the study include sixty (60) Grade 10 students of the Zamboanga del Sur National High School of School year 2015-2016. Two intact classes were utilized in the study which contains 55 and 52 students respectively. However, since this investigation used the static group comparison method, only 15 male and 15 female students from the experimental group is paired with 15 males and 15 females from the control group based on sex, and grades in science from the previous quarter. This is done to ensure total control over several possible intervening variables that would interfere in the variables involved in the study.

The control group of this investigation is aided with an activity in which they use real laboratory apparatuses while virtual laboratory materials were used by the experimental group using computer during the experimentation. A total of 10 class hours were used in the investigation wherein the two groups were exposed to normal classroom setting. However, they differ in terms of the specific laboratory material used that would aid them in understanding the concepts more.

To measure the academic performance of students a paper and pencil researcher made achievement test in physics-based from the K-12 learning competencies set by the Department of Education, aided by the table of specification (TOS) were constructed by the researcher. The questions formulated were from the three domains; Knowledge, Process, and Understanding. In addition, this test was validated and tried out by 30 grade 10 students from an annex school of the Zamboanga del Sur National High School at San Pedro, Pagadian City. This specifically intends to see the internal consistency of each item in the formulated achievement test.

In the final revised 30 items achievement test, every correct answer is given one (1) point and the perfect score is 30. A range was set by the researcher to assign the corresponding achievement level based on the K-12 Assessment scale to the scores obtained by the students as shown in Table I.

TABLE I. THE RANGE OF SCORES FOR THE ACHIEVEMENT LEVEL OF THE STUDENTS

Score Range	Achievement Level	Qualifying Statements
25-30	Advance	Highly proficient in ability, knowledge, and skills in Physics
19-24	Proficient	Proficient in ability, knowledge, and skills in Physics
13-18	Approaching Proficiency	Moderately proficient in ability, knowledge, and skills in Physics
7-12	Developing	Slightly proficient in ability, knowledge, and skills in Physics
0-6	Beginning	Not proficient in ability, knowledge, and skills in Physics

Necessary legal communications were followed to ensure that the proper protocol of the conduct of the investigation was established before the research was conducted. Confidentiality of the result of the investigation was emphasized to the student's respondents as well as to the teachers and head teachers involved which gains respondents their confidence participating in the said experimentation.

Appropriate statistical tools for analyses were applied. For problem 1, the Marginal Mean, Mean and SD were used to compare the achievement level of Grade-10 students applied with Virtual Laboratory Material and those who were taught using real laboratory apparatuses. For problem 2, the Analysis of Covariance (ANCOVA) at 0.05 level of significance were utilized to know if the academic achievement level of students in Physics applied with virtual laboratory would differ significantly with their achievement level if they were applied with real laboratory materials.

III. RESULTS AND DISCUSSION

A. Academic Performance Level of Students in Physics

The results from the pretest and posttest of the two groups, experimental and control group were reflected in Table II.

TABLE II. ACADEMIC PERFORMANCE LEVEL OF STUDENTS IN PHYSICS

GROUPS	N	$\overline{X}$	SD	ACHIEVEMENT LEVEL	$\overline{X}$	SD	ACHIEVEMENT LEVEL
Experimental	30	15.23	3.58	Approaching Proficiency	25.83	2.73	Advanced
Control	30	14.2	2.83	Approaching Proficiency	20.43	3.29	Proficient
Score Range		Experimental Group Posttest Scores			Control Group Posttest Scores		
		f	%	Achievement Level	f	%	Achievement Level
25-30		23	76.7		4		
19-24		6	20.0	Advanced	20	13.3	Advanced
13-18		1	3.3	Proficient	6	66.7	Proficient
7-12		0	0	Approaching Proficiency	0	20.0	Approaching Proficiency
0-6		0	0		0		
MEAN Difference *(Marginal Mean between Pretest and Posttest Scores)*		10.60			6.23		

It reveals that the two groups have almost the same level in terms of academic performance during the pretest. Both groups obtained approaching proficiency level which significantly ideal and favorable in the experimental procedure since it prevents external factors to intervene in the findings of this investigation. Moreover, the obtained standard deviation of each group reflects the homogeneity of the groups. The control group which obtained lower SD (2.83) in their pretest implies that students have close scores while the higher SD of the experimental group (3.58) could be attributed to their varied background knowledge of students about electricity which leads them into obtaining a dispersed score.

The low academic performance of students in both groups in the pretest could be due to their low interest in learning physics since much of the teaching procedures utilized by the teachers in their physics lessons involves activities that use real laboratory apparatuses which is defective and would not give accurate data results. O. Lhagva (2014), concluded that 21st-century students must be introduced with a virtual laboratory in the classroom teaching process because this would increase their academic performance and the old laboratory procedure using real laboratory apparatuses would become not interesting to them.

Table II also reflects the major difference between the academic achievement of the control group as well as the experimental group in the posttest results. One of which is the increase of each group's performance from the pretest to posttest. The experimental group yield higher increase of scores from the pretest to posttest (from 15.23 to 25.83) gaining a marginal mean of 10.60 compared to the control group which only gained a marginal mean of 6.23 (from 14.20 to 20.43). This is probably due to the laboratory activity and laboratory procedure being used in the learning process. Since students nowadays are inclined with the use of computers they find more interest in activities which utilize computer technology in their physics lessons. This corroborates to the findings of Sassi, E. (2000) on his research on the Advantages and Disadvantages of using virtual laboratories in physics education stating that it is advantageous to students to align their interest in learning to the activities that must be given to them because this would increase also their self-esteem and confidence in learning the concept if it is aligned with their personal interest.

Furthermore, a compelling greater difference with the control and experimental group were revealed in the scores of the students in the post-test. 76.67% from experimental group attained Advanced level while only 13.33% in the control group obtained advanced level. This means that 86.67% from the control group attained Proficient and approaching proficiency level while 23.33% in the experimental group obtained that level. This evidence is a clear manifestation that the application of virtual laboratory activities to students in physics could greatly influence their academic performance. Lkhagva Oidov, Ulambayar Tortogtokh, & Enkhtsetseg Purevdagva (2012) on their study on using virtual laboratories in Mongolia reveals that using virtual laboratories leads students to formulate fundamental laws in physics by manipulating the different variables virtually.

The result of this investigation confirms that exposure of students in the use of virtual laboratories would greatly influence the academic performance of students in physics. It is also evident during their activity that students eagerly cooperate in the activity due to the increase of their interest as computer manipulation was involved in the activity and they love using computers in learning. Students further attest that data obtained from the activity were more reliable and accurate since it is programmed based on real environmental probabilities. Colm O'SULLIVAN (2004) confirms that integration of these real laboratory conditions to an ICT based programs will allow users to experience environmental variables virtually like what is there in the real conditions. Furthermore, students interact with these variables easily without the risk of experimental hazards since it is only done on the computer.

In addition, the result of this investigation confirms that allowing students to use virtual laboratory can increase their academic performance in physics especially in the concepts of electricity. This also gives them confidence in formulating physics formulas that could aid them in understanding physical phenomena. Moreover, the application of virtual laboratory in physics gives teachers an easy task in establishing relationships between variables to the students because they will learn it by themselves as they use virtual laboratory software. J. Jorge, J.M. Mercadé, L. Conangla, & E. Ferreres (2007) who conducted a survey among students reveals that it is highly suggested by the students for computer engineers to formulate

virtual and digital software programs that could aid them in learning concepts in science that would involve animations and presentations on the interactions of various physical quantities for them to have a visual understanding of these natural phenomena.

B. Comparison of the Academic Performance Level of the Experimental Group and of the Control Group

To test if there is a significant difference between the pretest and the posttest scores of the control and the experimental group, the data were subjected with Analysis of Covariance (ANCOVA) shown in Table III.

TABLE III. ANALYSIS OF COVARIANCE (ANCOVA) TO COMPARE THE ACADEMIC PROFICIENCY LEVEL OF THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

Source	Type III Sum of Squares	df	Mean Square	F	p-Value
Corrected Model	542.983a	2	271.492	36.502	.000
Intercept	768.663	1	768.663	103.347	.000
Pretest	105.583	1	105.583	14.196	.000
Main Effects	360.658	1	360.658	48.490	.001
Error	423.950	57	7.438		
Total	33076.000	60			
Corrected Total	966.933	59			

a. R Squared = .562 (Adjusted R Squared = .546)

The data in Table III show that the Main Effects obtained a p-value of 0.001 lower than the significant level of 0.05; reveals that there is a significant difference in the academic performance level between students taught using virtual laboratories and the student's academic performance level taught using the conventional real laboratories. This implies that statistically, the performance of the two groups is not comparable thus; there is really a big difference in their performance as they were exposed to different laboratory procedures and apparatuses. The previous discussions on the mean difference of the two groups confirm that the application of virtual laboratory in physics gives more impact to the performance of the students in their test and could greatly increase their academic performance level.

Other studies suggested that showing students only with video presentation would not anymore lift students interest on the presentation because they would learn much if they were exposed unto manipulating the variables themselves by engaging a hands-on experience with the variables (Hoffmaster, S.,1991). Although it was also confirmed in the study that video presentation could also manage students to have a visual understanding of the interactions of the variables, however, students even gain higher visualization on the concepts if they were not only allowed to see but manipulate it as well. Furthermore, this explicit contradictions in the academic performance of the two group could also be attributed to the low quality of the different real laboratory apparatuses used, some of which are already old enough that it cannot anymore give accurate results and it adds more hustle to the students because sometimes the apparatus is difficult to manipulate due to its defects.

On the other hand, it is highly evident that computer software programs are constant in showing data result from the manipulation of this software making it be more interesting to the students and the manipulation would not entail huge amount of time in the manipulative process because it is not new to them and they are just like playing computer games in which they highly like. This corroborates to the findings of Colm O'SULLIVAN (2004) that if learners would be given the chance to choose virtual or real laboratories? They would not hesitate to engage in using virtual laboratories instead of the usual real ones. However, we cannot really go away with the idea that real laboratories are what our scientist really used in the field in discovering facts and scientific principles. However, with the given conditions of the real laboratory apparatuses that most schools have nowadays, students opt to consider using virtual laboratories than using real but defective ones.

To attain the goal to maximum learning and increased academic performance level of students in physics, the educational process must not only be limited unto short discussion and lecture methods teachers must engage them into a much more interesting activity with the aid of virtual laboratories. The educational system with the developed instructional materials needs to consider the use of virtual laboratories. This could ensure an increase in students' participation, teachers' wider innovation in their approaches as well as decreasing the hustle in preparing the apparatuses, and finally increase student's academic performance level.

IV. CONCLUSION AND RECOMMENDATIONS

It can be inferred from the findings that the students who were exposed in using virtual laboratory activity had exceeded the core requirement in terms of knowledge, skills, and understanding in learning physics electricity concepts and can transfer those learning automatically and flexibly through authentic performance task. Students who perform physics experiments using virtual laboratory show competence, willingness, and eagerness in learning physics concepts on electricity compared with those who perform physics experiments using real laboratory apparatuses; thus, the use of virtual laboratory activity increases students' academic performance compared with the use of real laboratory apparatuses since the use of virtual laboratory brings about good practices in physics teaching, Instructional materials including that of other field in science should be applied with virtual laboratories to enhance the student's academic performance level.

REFERENCES

[1] J. Jorge, J.M. Mercade, L. Conangla, E. Ferreres (2010) Making Virtual Learning Environment for Non-Assisted Physics Laboratory, Universitat Politecnica de Cataluna Press, April 2012

[2] Slavko Kocijancic and Colm O'Sollivan (2004),Real or Virtual Laboratories inScienceTeaching – is this Actually a Dilemma?Informatics in Education, Institute of Mathematics and Informatics, Vilnius.

[3] Lkhagva Oidov, Ulambayar Tortogtokh and Enkhtsetseg Purevdagva (2012), Virtual Laboratory for Physics Teaching, International Conference for Management, Education and Innovation, IPEDR, IACSET Press Singapore.

[4] O. Lhagva (2014). The need to introduce a virtual laboratory for physics teaching. Teacher newspaper, 2004, № 13/57/, in Mongolia.

[5] Sassi, E. (2000). Computer-supportedlab-work in physics education: advantages and problems, International Conference on Physics Teacher Education beyond 2000, Barcelona (cdrom).

[6] Y Hoffmaster, S. (1991).Using video equipment as a physics laboratory tool. Am. J. Phys.59 (4), 375-376, April 1991.

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