CONCEPTUAL UNDERSTANDING IN PHYSICS USING COMPUTER SIMULATION VERSUS CONVENTIONAL LABORATORY EXPERIMENT

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Abstract

This study aims to determine the conceptual understanding in Physics using computer simulation versus conventional laboratory experiment. The sample consisted of 60 grade 7 students and 80 grade 9 students from Malaybalay City National High School for the school year 2017 - 2018. The respondents were selected using simple random sampling. The study made use of quasi-experimental pre-test post test research design. Two groups of grade 7 students and another two groups of grade 9 students were involved in this study. The experimental group from grade 7 and grade 9 level were taught using computer simulation while the control group from grade 7 and grade were taught using conventional laboratory environment . The Physics Education Technology (PhET) simulation software program was used in computer simulation. There were four research instruments used in the study: the achievement tests in motion in one dimension that obtained a computed Cronbach alpha of 0.754 and the achievement tests in motion in two dimension that obtained a computed Cronbach alpha of 0.806 for its reliability coefficient. The manual of the lesson in teaching computer simulation were also constructed. The achievement test was administered as pre-test and posttest. The data gathered in the pre-test and post-test were analyzed by computing the mean, standard deviation and were subjected to one way analysis of covariance at $p = 0.05$ level of significance. The findings showed that the students in grade 7 and grade 9 from the experimental group achieved higher scores than the students from the control group. There is a significant difference in the post-test scores between the

two groups of students in favor of those students in the experimental group. The results showed that computer simulation can be used as replacement for real laboratory experiment.

Keywords: computer simulation, conventional laboratory experiment, motion

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Leah K. Pacudan
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I. CONTEXT AND RATIONALE

Computer simulations refers to computer experiments because they share much in common with laboratory experiments (Gould et al., 2005). Computer simulation played an important role in complex science (Plass et al, 2012). Computer simulation is designed to address common misconceptions in science. The expert like models are made more explicit, guidance and feedback is built within and is quite engaging. This implicit guidance can reduce the time students spend “getting stuck” trying to figure things out. It also allows students to go much deeper into the material without explicit guidance or feedback from the teacher (Wieman, 2010).

In physics education, students’ have difficulties in acquiring concepts because they construct ideas from the interaction with the physical world which are not consistent with scientifically accepted ideas (Baser and Durmus, 2010). They often hold misconceptions be they historical, mathematical, grammatical, or scientific. Computer simulations have been investigated as means to help students confront and correct these misconceptions, which often involve essential learning concepts (Strangman and Hall 2009).

The use of computer simulation in classroom instruction is supported by the Department of education in the Philippines as information and communication technology that helps students cope with the 21st century learning (DepEd order no. 35, s2016). It is within the mandate of the Dep-Ed Computerization Program (DCP) to improve instruction in the recipient schools with the use of computers (DepEd Order no. 78, s.2010) .

The Department of Education also aims to improve classroom instruction that boosts students’ performance through encouraging research to improve the teaching and learning process (DepEd Order no. 39, s2016). Thus, the researchers conducted

a study to use computer simulation to solve problems on students' misconception of the lesson, to perform experiments which could not be attained due to inadequacy of apparatus and time constraints in achieving the learning competencies.

II. Innovation, Intervention and Strategy

This study uses computer simulation and conventional laboratory experiment as an intervention to improve the students' academic achievement. Two intact classes was used for grade 7 level and another two intact classes for grade 9 level. The experimental group was exposed to computer simulation, while the control group was exposed to conventional laboratory experiment.

III. Action Research Questions

This study attempts to investigate the conceptual understanding in physics among grade 7 and grade 9 students . This was conducted at Malaybalay City National High School during the school year 2017-2018.

Specifically the study sought to answer the following problems:

1. What is the proficiency level and academic achievement in Physics of:
    a. students taught using conventional laboratory experiment and
    b. students taught using computer simulations?
2. Is there a significant difference in the academic achievement in Physics between students taught using conventional laboratory experiment and students taught using computer simulations?

IV. Action Research Methods

The study employed quasi-experimental pre-test and post test research design to test the effects of exposing students to computer simulation and exposing students to conventional laboratory experiment. The study was conducted at Malaybalay City National High School during the school year 2017 - 2018.

A letter for permission was sent to the school head for the conduct of the study. The present study utilize two intact classes from grade 7 and another two intact classes from grade 9. Each grade level has a control group and experimental group. There are 60 grade 7 and 80 grade 9 students of Malaybalay City National High School for the school year 2017 -2018 chosen as participants of the study. There are 30 grade 7 students from the control group and another 30 grade 7 students from the experimental group. On the other hand, each intact class of grade 9 consisted of 40 respondents. These students were grouped heterogeneously upon enrollment and were selected using simple random sampling.

The instruments used in the study were the manual in teaching physics, achievement tests, and PhET Computer simulation. Furthermore, the lesson plan for the computer simulation for the experimental group and lesson plan for the conventional laboratory experiment were developed to guide the teachers and the students on the activities and to facilitate the teaching-learning processes.

The manual for the lesson in the experimental group and in the control group are parallel based on the K-12 Learning Competencies. The grade 7 Physics lessons includes motion in one dimension and grade 9 physics lessons includes motion in two dimensions. The lesson plan in the experimental group and in the control group are parallel to the K-12 learning competencies and was based on Deped order no. 42, s. 2016.. For the experimental group, the lessons include introductory activities and developmental activities using computer simulation while for the control group, the lessons include introductory activities and developmental activities using conventional laboratory experiment. The lesson plan in the teacher's manual serves as a guide for the teacher in the conduct of the lessons in both the control group and the experimental group.

There were two achievement tests constructed. The grade 7 achievement test that includes questions on motion in one dimension and the grade 9 achievement

test that includes questions on motion in two dimensions. Both are a 30-item teacher made test. The 30-item test was matched with the lessons in the control group as well as to the experimental group. The grade 7 achievement test was tried out to grade 8 students who already took lessons in motion in one dimension. The computed Cronbach alpha is 0.754. On the other hand, the grade 9 achievement test was tried out to grade 10 students of Malaybalay City National High School. These students took lesson in motion in two dimension in their grade 9, The reliability coefficient of the test was computed after the try out using Cronbach alpha. The computed Cronbach alpha is 0.806. The reliability coefficient shows that the achievement test was reliable and dependable to assess the conceptual understanding in physics of the grade 7 and grade 9 junior high school students.

The test was based from the table of specification prepared by the researcher. The test items were formulated based on the domains of remembering, understanding, application, analysis and evaluation. The test items constructed are within the comprehension and readability levels of the grade 7 and grade 9 students.

Each correct answer in the achievement test was given one (1) point. For a total of 30 items achievement test, the perfect score is 30. The equivalent proficiency levels of the scores obtained by the students was based on Deped order no. 8 s. 2015.

The data gathered in the posttest were analyzed using frequency, means and standard deviations. ANCOVA analysis were used to determine the significant difference in the achievement test scores between the students taught using computer simulation and students taught using conventional laboratory experiment.

V DISCUSSION OF RESULTS AND REFLECTION

A. *Achievement Test Mean Scores of the Experimental Group and the Control Group*

The proficiency level and mean scores from the pre-test and post test result of the two groups , the experimental and the control groups in grade 7 and grade 9 are presented in Table 1.

The data from table 1 reveals that the scores of the students from the experimental and control group increases after exposure to computer simulation and conventional laboratory experiment respectively as manifested in their pre-test and post-test scores. Furthermore, the grade 7 and grade 9 students taught using computer simulation gains higher academic achievement compared to the grade 7 and grade 9 students that are taught using conventional laboratory experiment as shown in their post test scores. The grade 7 students from the experimental group attains a satisfactory proficiency level while the grade 9 students from the experimental group attains very satisfactory proficiency level.

On the other hand, the grade 7 students from the control group did not meet the expectations while the grade 9 students from the control group achieved satisfactory proficiency level. The scores of the grade 7 students exposed to computer simulation is widely dispersed compared to the scores of the grade 7 students exposed to conventional laboratory experiment. On the contrary, the scores of the grade 9 students taught using computer simulation is slightly less scattered compared to the scores of the students exposed to conventional laboratory experiment.

The data also shows that there are more grade 7 and grade 9 students from the experimental group achieved an outstanding, very satisfactory and satisfactory proficiency level compared with the students in the control group. Many grade 7

Table 1. Proficiency level and academic achievement of students from the experimental group and the control group.

Level of Proficiency	Range of Scores	Control Group				Experimental Group			
		Pretest		Posttest		Pretest		Posttest	
		f	%	f	%	f	%	f	%
Grade 7									
Outstanding	26-30							1	3.33%
Very Satisfactory	23-25			1	3.33%			9	30%
Satisfactory	20-22			1	3.33%			6	20%
Fairly Satisfactory	18-19			3	10%			8	26.67%
Did Not Meet Expectations	0-17	30	100%	25	83.33%	30	100%	6	20%
X		7.6333		15.6000		7.6333		20.4000	
SD		1.60781		2.56770		1.58622		3.48989	
Proficiency level		Did Not Meet Expectations		Did Not Meet Expectations		Did Not Meet Expectations		Satisfactory	

Grade 9		Pretest		Posttest		Pretest		Posttest	
		f	%	f	%	f	%	f	
Outstanding	26-30							15	37.5%
Very Satisfactory	23-25			12	30%			17	42.50%
Satisfactory	20-22			13	32.5%			6	15%
Fairly Satisfactory	18-19	1	3.33%	9	22.5%	1	3.33%	1	2.5%
Did Not Meet Expectations	0-17	39	96.67%	6	15%	39	96.67%	1	2.5%
X		11.80		20.5250		11.8750		24.30	
SD		2.59388		2.69841		2.50320		2.66218	
Proficiency level		Did not meet expectation		Satisfactory		Did not meet expectation		Very Satisfactory	

Legend:SD- Standard deviation x-mean f-frequency % -percentage

students from the control group did not meet the expectation while the grade 9 students from the control group attains satisfactory achievement level.

Evidently, grade 9 students in the experimental group are highly proficient in the knowledge and skills in motion on two dimension and the grade 7 students are moderately proficient in the knowledge and skills in motion on one dimension. The grade 9 students from the control group is moderately proficient in the knowledge

and skills in in motion on two dimension while the grade 7 students from the control group needs improvement in the knowledge and skills in motion in one dimension.

The data implies that computer simulation is more effective in improving the students' conceptual understanding in physics particularly in topics in motion compared to conventional laboratory experiment. The students ability to synthesize the relationship among variables in the experiment is develop more when the students do computer simulation since the students can easily repeat the experiment in a given time as compared to the conventional laboratory experiment which consumes longer time in repeating the experiment.

The students gain wider understanding in motion on one dimension for grade 7 students and two dimension for grade 9 students as they clearly visualize the motion of an object even in the perspective that involves greater distances and in wider perspective. In a conventional laboratory experiment the distances observe are those that is within the limit of what the students can see inside the classroom or within the school campus. Thus, it would be difficult for the students to gain higher understanding if the situation applied includes wider perspective. On the other hand, in computer simulation the students can visualize the path of an object especially the trajectory path at varied angles for motion of an object in two dimensions. This promotes wider understanding on how one variables affects one another with the use of computer simulation.

The study supported the study of Widiyatmoko (2018) which indicates that simulations work to improve understanding the concept of science, not only students' understanding but also pre-service teachers' understanding. The outcome of the study is also in consonant with the study of Azar and Sengulec (2010) which shows that computer-assisted teaching method can be more effective than the laboratory-assisted teaching method. The result of the study also conforms with the study with Tarekegn, (2009) which showed that exposure to computer simulation enhance students achievement. However, it contradicts with the result of Baser and Durmus

(2009) which showed the same effects on acquisition of scientific concepts between individuals is exposed to virtual laboratory experiment and real laboratory experiment.

B. *Comparison of the Academic Achievements in Electricity Between the Students from the Experimental Group and the Students from the Control group*

In order to test the significant difference in the posttest achievement scores between the students from the experimental group and the control group, the data gathered were subjected to one way analysis of covariance. The result is presented in Table 2.

Table 2. ANCOVA Results of the Pretest and Posttest of the Experimental and Control Groups

Grade 7

Groups	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	684.780	2	342.390	95.099	.000
Intercept	101.072	1	101.072	28.073	.000
Pretest (cov.)	339.180	1	339.180	94.207	.000
Group (1 & 2)	345.600	1	345.600	95.991	.000
Error	205.220	57	3.600		
Total	20330.000	60			
Corrected Total	890.000	59			

Grade 9

Groups	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	321.349	2	160.675	23.609	.000
Intercept	1281.231	1	1281.231	188.259	.000
Pretest (cov.)	36.337	1	36.337	5.339	.024
Group (1 & 2)	281.925	1	281.925	41.425	.000
Error	524.038	77	6.806		
Total	41031.000	80			
Corrected Total	845.387	79			

α = 0.05 significance level

The data in table 2 shows that there is a significant difference in the post-test scores between the students exposed to computer simulation and the students exposed in conventional laboratory experiment as shown by the computed p-value which is less than the set level of significant 0.05 in favor of the students exposed to computer simulation.

The result showed that students taught using computer simulation significantly gains more conceptual understanding that the students taught using conventional laboratory experiment. The visual presentation offered by computer simulation enables the students to understand better the concepts on motion and arouses their interest as shown in their eagerness to do computer simulation in computer laboratory. Thus significantly improve the academic achievement of the students compared to conventional laboratory experiment.

The result of the study is in consonance with the outcome of Asiksoy (2015) which claims that students who were taught using simulations were more successful than the students of the control group who were taught by the traditional approach. Also, it was determined that students were satisfied by simulation-based Physics education. The study has similar result with the study of Banik (2017) which showed that computer assisted instruction is effective in terms of the achievement of learner in teaching Physics at Posttest stage.

From the analysis of the study the researcher therefore inferred that computer simulation is an educational tool that improves the teaching and learning process. With the significant difference in the academic achievement between students exposed in computer simulation and students taught using conventional laboratory experiment, then computer simulation is effective in improving the students conceptual understanding can be used in replacement of laboratory experiment in the absence of laboratory materials, time constraints and in lieu of the experiment which pose dangers to the students.

Based on the findings, science teachers are encouraged to expose students in virtual learning environment to enhance student's learning and student's academic achievement. However, trainings for science teachers in using computer simulation should be conducted for the assurance of effective delivery of the lessons with the use of computer simulation.

VI Action Plan

Task	Date										
	October, 2017			November, 2017			January, March 2018	March to May 2018	June 2018	July 2018	August, 2018 to 2019
	2	9 to 13	16 to 20	6 to 10	13 to 17	20 to 30					
Submission of letter for permission to conduct the study											
Making of lesson plan and achievement test											
Launching of the achievement test for reliability test and cron bach alpha analysis											
Implementation of the research											
Analysis and interpretation of the gathered data											
Finalization of research paper											
Submission of papers in the division											
Dissemination of Action Research											

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VIII FINANCIAL REPORT

	Quantity	Unit price	Total Amount
BERF FUND			25, 500.00
Expenses			
a. Office supplies			
Book paper (A4)	30 reams	206.00	6, 180.00
ink	5 sets	1, 372.00	6, 860.00
Sign pen	5 box	300.00	1, 500.00
Correction pen	10 pcs	27.00	270.00
Correction tape	11 pcs.	220.00	220.00
b. E- load			1, 800.00
c. transportation			1, 000.00
d. Bookbinding	7 books	200.00	1, 400.00
e. Meals and snacks			6, 270.00
Total Expenses			25,500.00
BERF FUND less Expenses			0