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Interactive Simulations in Teaching Linear Equations

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Abstract: The study was a quasi-experimental type of research intended to find the effectiveness of the use of Physics Education Technology (PhET) simulations in teaching linear equations. These lessons were part of the Mathematics 8 curriculum of the Department of Education. The evaluators in this study were Math teachers from the public junior high school in Cluster 1, Division of Pampanga. Thus, they had an evaluation on the teacher-made test which served as the main instrument to gather participants' performance. The gathered data were tabulated, analyzed and were subjected for interpretation using frequency counts, percentages, mean and standard deviation. The study revealed that participants improved their performances on the linear equations after their exposure to PhET simulations and Conventional teaching. Significant differences from their pretests and posttests scores were obtained by the participants of both groups. Also, it was found out that there was no significant difference on the PhET simulations and conventional teaching pretests scores while there was a significant difference in their posttests scores. The results of this study show that the use of PhET simulation in learning the linear equations improved the performance of the participants.

***Index Terms* - PhET simulations, conventional teaching, linear equations, teaching methodology**

I. Introduction

Technology has been part of every student's quest for knowledge. It gives student access to an abundance of information. It also changes rapidly in terms of technological tools which help the students gain understanding at his best. This technology serves as a vehicle for collaboration and makes individual contributions to accomplish the task. Also, technology affects not only the way of living but also the way of learning of students at the school. Discussions at school incorporated the use of technology. As evidence, teachers utilize computer inside the classroom.

Today, numerous ICT applications are available, aiming to stimulate student's active engagement. One of them is computer simulations (Jimoyiannis & Komis, 2000). Simulation is a teaching strategy that integrates cognitive, affective, and psychomotor learning domains as one and allows learners to apply theory to practice (Ross & Bruce, 2012). It also helps students learn basic knowledge (Zhang, 2011).

The use of ICT changes the nature of teaching and learning. Through technology, the teaching profession evolves from a teacher-centered to student-centered instruction (Webb, 2005). Technology helps the students to process learning by guiding them and explaining the lessons through an interactive simulation. These simulations make students to visualize their topics and interact with the technology in doing activities.

Simulation method in teaching may enhance the students' capabilities to analyze and understand information that challenges them in making critical decisions. Simulation method provides learners a new and direct learning experience that gives on the spot feedbacks for their performance and offers opportunities for fruitful classroom interaction (Robert, 2011).

Computer simulations are therefore computer-generated versions of real-world objects. These 'provide near-authentic environment, context, and situation for task-based learning' (Chen et al. 2013, p 172).

Through the Republic Act 10533 otherwise known as the Enhanced Basic Education Act of 2013, the K to 12 curricula has implemented to develop 21st -century learners who can create, evaluate, and effectively use information, media, and technology. The Department of Education has exerted more efforts to facilitate learning and enhance learners' performance through the provision of modern instructional tools by implementing the computerization program.

Math is most widely known to be difficult, obscure and of little interest to certain people. Also, the study of Math carries a stigma that only the people with mental aptitude with numbers consider Math as usual. Mathematics plays a significant role in the application of basic numeracy skills and the development of student's logical thinking and higher-order cognitive skills. Moreover, Mathematics has a vital part in numerous scientific fields such as physics, engineering, and statistics. Therefore, a positive attitude towards Mathematics among students is a significant goal of Mathematics education in many jurisdictions (Ganal, Nicette N., Guiab, & Marissa R. 2014).

As far as students are concerned, it is generally alarming that Filipino students tend to excel in knowledge acquisition but turn out to be considerably low in lessons that require higher order thinking skills. This sorry state is apparent in students' performance in the national and international surveys on Mathematics and Science competencies. Separate studies on Mathematics performance of pre-service teachers (Philippine Daily Inquirer, 1988, p. 14 and Ayap, 2007) and the 1993 and 1994 Professional Board Examination for Mathematics Teachers

(Ibe, 1995 and Aguinaldo, 2008) concurred with current literature that the same dismal picture of Mathematics competencies both of those who intend to teach it and those who have been teaching in the elementary and secondary levels.

Physics Education Technology Simulation

About these difficulties in Mathematics, interactive simulations play a vital role in applying basic numeracy skills. Interactive simulations, real-time visualizations, and virtual manipulative aids in making Math concepts easier to internalize for almost all students and PhET's tools are some of the suggested aid in teaching. A variety of useful tools (PhET Interactive Simulations: Math, 2016) ranging from early fundamentals like arithmetic, fractions, and estimation to advance concepts of probability, trigonometry and calculus are accessible for most classes of the K-12.

PhET Interactive Simulations, founded by Nobel Laureate Carl Wieman in 2002 at the University of Colorado creates free interactive Math and Science Simulations. The Philippine simulations aimed at engaging students in an intuitive, game-like environment where they learn through exploration and discovery.

The acronym PhET stands for Physics Education Technology, but due to the inclusion of simulations for many other subjects aside from Physics, the acronym becomes too limited. However, the PhET team opted to retain the name as it is already widely known. The PhET is a site of research-based interactive computer simulation in teaching and learning Physics, Math, and other sciences which can either be run online or downloaded for free from the PhET website. The link between the real-life phenomena and the underlying science which leads to visual and conceptual models accessible to students, simulations become engaging, interactive and game-like environments because learning emphasizes through interactive exploration. PhET simulations are first developed for and tested with university and high school students but are educational and amusing for students from grade school to graduate school (Weiman, 2002).

Perkins (2015) stated that the PhET Interactive Simulations project is addressing a great challenge confronting the nations across the world: educating the future generation of scientists, mathematicians and engineers and increasing the global science literacy through information and education of the varied array of people about science, math, and engineering issues.

Moreover, PhET Interactive Simulations at the University of Colorado Boulder addresses the need to improve K-20 science education for the US and the world, as numerous reports call to increase the number of students pursuing technical fields, prepare graduates to enter the procedural workforce and lead practical innovation.

Weiman, (2002) added that the PhET project had developed over 130 research-based interactive simulations that are transforming the teaching and learning of science and math. Students learn through scientist-like exploration on simulators that are animated, interactive, and game-like environments. They emphasize the connections to the real world, make the invisible visible, and include the visual models that the scientists make use. The adaptable design allows them to be used in multiple environments such as lectures, labs, and homework. The simulators have been translated to over 70 languages and can be run online or downloaded for use offline.

Physics Education Technology (PhET) as a Pedagogical Approach

A study used the computer program "Webber Interactive WH Questions Program" in answering Kindergarten students' higher- order thinking skills performed better at answering why questions than their peer who did not receive computer-based instruction. (Bradberry-Guest, 2011).

Prensky (2009) believes that digital technology does not only make people smarter but also wiser. As a result, he defines "Digital wisdom" as the wisdom that arises from the use of digital technology to access cognitive capabilities beyond the innate ability, as well as the knowledge to use technology prudently to improve qualities.

In the study of Dela Cruz (2015), students not only performed better after their exposure to computer simulations than those exposed to conventional teaching, but also students participated more actively in the discussion of selected Physics topics.

Additionally, Balakrishnan and Woods (2013) reported that manual physical and computer -simulated experiments support and complement each other in the teaching-learning process.

The use computer simulations has been reported that learners gained up to a maximum effect size of 1.54 (Rutten et al. 2012; Donnelly et al. 2012) and other achievements were reported by Howe et al. (2013) where children worked in pairs than working individually.

Computer simulations specifically Physics Education Technology (PhET) can be utilized in teaching Mathematics meaningfully (Perkins, 2015). Lobato and Siebert (2002) examined student understanding of slope in actual situations as a measure of the steepness of a ramp, and slope in useful conditions as a measure of speed or rate of change where the students think of the mobile speed differently from the steepness of the ramp. Furthermore, their study emphasized the importance of context in conceptualizing the slope and the student's difficulty in transferring knowledge across contexts which is often overlooked by curriculum developers and instructors.

On the other hand, Davis (2007) analyzed eight sophomore and junior students enrolled in Algebra II on their understanding of the y-intercept in real-world contexts and across multiple representations in 10 weeks of instruction. Throughout the study, with an approach that delayed the introduction of formal mathematical terminology which allowed students to utilize their terminology, Davis observed and interviewed the students. Detailed analyses of student performance showed a weak connection between the various representations of the y-intercept and the students' use of invented terminology. Furthermore, Davis explained these findings as being influenced by the students' prior knowledge of the y-intercept in real contexts and the teacher's idea of the y-intercept with his assumptions that students do not have difficulty understanding the relationship between the formal and informal mathematical language suggested by the real-world contexts.

Linog, Lahoylahoy, and Alguno (2013) claimed as the results of the PhET-aided developed enrichment activities are usable and acceptable as instructional materials based on the evaluation of public secondary Physics teachers. Although both groups gained significantly in their post achievement tests, the treatment group had a considerable increase compared to the control group which implies that learning is the best achieved and observed through PhET simulations that addressed misconceptions, visualized concepts and experienced interactive community.

Computer simulations specifically Physics Education Technology (PhET) can be utilized in teaching Mathematics meaningfully (Perkins, 2015).

Lobato and Siebert (2002) examined student understanding of slope in actual situations as a measure of the steepness of a ramp, and slope in actual settings as a measure of speed or rate of change. Nine students from Grades 8 - 10 with an average performance in Mathematics participated in this study. Relatively, analyses revealed those students' difficulties in making inference on the physical of slope and the functional aspect as the rate of change. Lobato and Siebert concluded that students think of the mobile speed differently from the steepness of the ramp, because, mathematically, the speed magnitude and slope as a measure of the steepness expressed by the same formula. Lobato and Siebert's study emphasized the importance of context in the conceptualizing slope and student's difficulty in transferring knowledge across contexts which is often overlooked by curriculum developers and instructors.

Impact of PhET on the Performance of Students

The effect of technology on education has been so considerable that it has led to the appearance of new educational philosophies such as "Digital Wisdom" (Prensky, 2009).

Research shows that computer simulations have different effects on students depending on their academic levels or abilities. Computer simulations provide students with an open-learning environment that gives them an opportunity to develop an understanding of physical occurrences and laws by developing hypothesis and testing ideas; develop an understanding of the relations between physical concepts, variables and occurrences by isolating and manipulating parameters; utilize a variety of representations including pictures, animations, graphs, vectors and numerical data displays which help them understand the underlying concepts, relationships, and processes; demonstrate their portrayal and mental models of the physical world and employ an investigative approach about occurrences that are hard to experience in a classroom or lab settings, due to complexity, technical difficulty, money or time consumption, or they occur too fast to be understood by just observing them in real- life settings (Jimoyiannis & Komis, 2001).

In the Philippines, computer simulations in Mathematics not customarily used compared to Science and Technology. International Mathematics Olympiad showed details of the Philippines ranking 79th out of 82 countries in 2003 and on the 80th place out of 85 in 2004. Relatively, China got the highest score of 220 out of the maximum possible points of 225 while Vietnam got 126, Thailand 9 and the Philippines 16 points (DepEd, 2003).

Cited studies found the use of PhET Simulations on teaching Science lessons effective. The University of Colorado stated that there are lessons in Mathematics such as area builder, area model algebra, area model decimals, area model multiplications, arithmetic; build a fraction, calculus graph, equation graph, graphing lines, graphing slope intercept, fraction matcher and others through PhET Simulations discussion.

The studies of Balakrishnan and Woods (2013), Davis (2007), Dela Cruz (2015), Linog, Lahoylahoy and Alguno (2013), Lobato and Siebert (2002) and (Perkins, 2015) concentrated on the use of interactive simulations in teaching and learning process and found out that there was an increase in the academic performance of the students after their exposure to interactive simulations. These studies focused on the use of interactive simulations as the teaching approach. Moreover, most of the studies used interactive simulations in science subjects abroad while this study will use it in Mathematics teaching and Philippine settings.

They are using simulations gives student concrete on how simulations work and to think like a scientist doing scientific work. It helps the student understand linear equations in a more interactive way.

Using the simulations teachers' methodology becomes advance and incline with the use of technology; thus; classroom discussions are more interactive and efficient for both students and teachers.

In more developed countries like the USA, Japan, Australia, and other school administrators provide an in-depth understanding of how simulations works inside classroom discussions. This methodology may serve as an example to the officials of the Department of Education particularly school administrators to incorporate more simulations in teaching different subjects like mathematics, science or physics.

The researcher is a grade 8-teacher who found out the skills learned related to graphing lines and slope intercept were reported to be one of the least-mastered in the second quarter examination of the previous school year. About this, the researcher would like to conduct this study about the use of PhET simulations in teaching linear equation.

Thus, the researcher wanted to find out if PhET was also effective in teaching Mathematics.

Theoretical Framework

This study involved the cognitive theory of multimedia learning (CTML). CMTL centers on the idea that learners try to form meaningful connections between words and pictures and that they learn deeper than they could have with words or pictures alone (Mayer, 2009). According to CTML, one of the principal aims of multimedia instruction is to encourage the learner to build a coherent mental representation from the presented material. The learner's job is to make sense of the viewed material as an active participant, eventually constructing new knowledge.

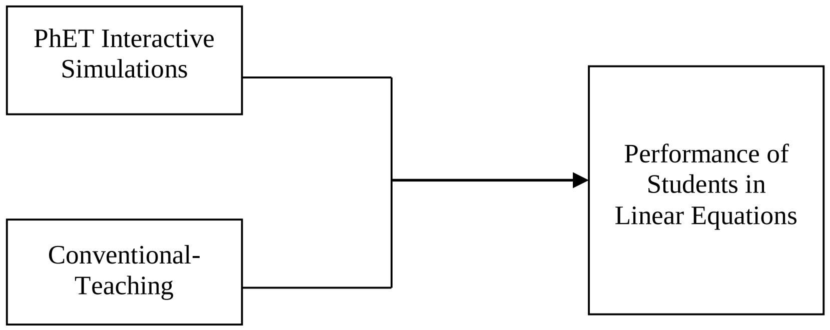
Mayer and Moreno (1998) and Mayer (2003) emphasized that CTML is based on three assumptions: the dual-channel assumption, the limited capacity assumption, and the active processing assumption. The dual-channel assumption is that working memory has auditory and visual channels based on Baddeley's (1986) theory of working memory and Paivio's (1986; Clark and Paivio, 1991) dual coding theory. Second, the limited capacity assumption is grounded from cognitive load theory (Sweller, 1988, 1994) and states that each subsystem of working memory has a limited capacity. The third assumption is the active processing assumption which suggests that people construct knowledge in meaningful ways when they pay attention to the related material, organize it into a coherent mental structure, and integrate it with their schema (Mayer, 1996, 1999).

Conceptual Framework

The study is a quasi-experimental research involving teaching methods as the independent variables and the performance of students in Linear Equations as the dependent variables. Two teaching methods were employed namely: PhET and Conventional teaching.

Computer simulations specifically Physics Education Technology (PhET) can be utilized in teaching Mathematics meaningfully (Perkins, 2015), while conventional teaching, in this study, refers to the use of chalk and board for the teachers; pen and paper for students. The teacher employs other traditional methods including demonstrations through examples, lectures, question and answer methods among others.

This study aims to prove the significant difference between the performance level of the students in linear equations through PhET Interactive Simulations and Conventional- Teaching.



The Paradigm of the Study

Research Problems

This study intended at determining the effects of interactive simulations in teaching linear equations. It specifically seeks answers to the following questions.

1. How may the performance of PhET Simulations and Conventional teaching groups be described in their pretest and posttest scores in linear equations?
2. Is there a significant difference between the pretest and posttest scores of the PhET Simulations and Conventional Teaching groups?
3. Is there a significant difference between the performance of participants exposed to PhET Simulations and Conventional Teaching regarding pretest scores and post-test scores?

Hypotheses

1. There is no significant difference between the pretest and post-test scores of the following group of participants: PhET Simulations and Conventional Teaching.
2. There is no significant difference between the performance of participants exposed to PhET Simulations and Conventional Instruction in regards to pretest scores and post-test scores.

II. METHODS

This study utilized quasi-experimental method. The present study used two whole classes to gather data. One class was taught using PhET simulations in their linear equations activities while the other, the control group, was taught through conventional teaching. In Quasi-experimental method, individuals were not randomly assigned (Creswell, 2013).

Participants

The participants in this study were grade 8 students of Justino Sevilla High School for the S. Y. 2018 – 2019. Justino Sevilla High School, located in Mangga Cacutud, Arayat, Pampanga, is the largest school in terms of population in the Division of Pampanga. Sectioning is heterogeneous.

One hundred Grade 8 students where most of them have low performance in Math as shown in their average which ranges from 75-78 were the participants. The experimental group had 26 female and 24 male participants while conventional had 22 female and 28 male participants. The researcher chose these two groups from five sections she handled. The experimental group was the 1:15 P.M. to 2:15 P.M. class while the 2:15 P.M. to 3:15 P.M. class was the control group. Moreover, five teachers from five public schools who are teaching Grade 8 Math served as the evaluators of the teacher made test.

Instruments

The chief instrument of this study was a 15-item multiple choice teacher-made test composed of graphing lines and graphing slope intercepts. The researcher also constructed a table of specification. The chart of the specifications gave the number of test items by content and their percentages, and the number of days each objective taken.

The instrument was evaluated by five teachers who specialized in Mathematics from Camba High School, Gatiawin High School, Arayat National High School, Sta. Ana National High School and Candating High School.

Pilot testing was administered among the 30 grade 8 students at Sta. National High School. Results of the pilot testing were subjected to items analysis. The analysis found items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14 and 15 were accepted based on the guidelines of the item analysis used in the Division of Pampanga while item 13 needed with slight revision. Item 13The points (-2, 5) and (4, -7) find the slope of the line revised into Find the slope of the line that contains the points (-2, 5) and (4, -7). The evaluators of the teacher made test agreed on the said revision.

Procedure

The researcher asked permission from the office of the principal for the conduct of the study and the utilization of the computer room for discussion. The teacher-researcher discussed the lessons using PhET Simulations for the experimental group and conventional teaching for the control group where the teacher used some materials such as visual aids, chalk, and board while PhET simulations, the computer room was utilized for the students to follow the discussion. Five teachers from five public schools who are teaching Grade 8 Math served as the evaluators of the teacher made test. Pilot testing followed after the face validity of the instrument had established. The teacher-researcher administered the pretest to both groups and retrieved after.

The teacher-researcher used PhET simulations in teaching graphing lines and graphing slope intercept to the experimental group, while the conventional teaching was for the control group. For PhET simulations the researcher asked the assistance of the ICT teacher-in-charge of the computer laboratory. Each participant used a computer to follow the discussion using interactive simulations. For lesson such as obtaining the equation of the line which was not available in PhET simulation, the teacher used power point presentation. This method of teaching did not use chalk and board. It relied on the use of computer simulations all throughout the class discussions.

The teacher-researcher discussed the same topics in both groups. For conventional teaching group, the teacher used visual aid and chalk and board for computation. Students followed the discussions by solving the equation on the board or using their notebooks as seat works. Visual aids made of manila paper and cartolina and the chalk and board utilized by the teacher-researcher in the conventional-teaching method. She observed the absence of technology in teaching linear equations for this group. She allotted a two-week lesson for discussion related to linear equations. Both groups took the posttest after the discussion. Teacher-researcher gave each respondent an hour to answer the test and retrieved the posttest questionnaires after the group had answered the questions.

The researcher served as the teacher of the two groups. She treated the groups with more or less the same environmental condition such as lighting and ventilation of rooms used and class schedules.

Weighted mean, frequency counts, and percentages were used to determine the scores of the participants in their pretest and posttest. Standard deviation and t-test were utilized to compare the effects of two methods of instruction.

To assess the performance of the participants, the teacher-researcher used the following scale which was adopted from DepEd Order no. 8, s. 2015 Policy Guidelines on Classroom Assessment for the K to 12 Basic Education Curriculum used. Kabigting and Nanud (2020) followed the same guidelines on assessment to measure the performance of ESL learners in the Philippines.

Score	Descriptive scale	Remarks
14.5 – 15.0	Outstanding	Passed
12.5 – 14.49	Very Satisfactory	Passed
10.5 – 12.49	Satisfactory	Passed
7.5 – 10.49	Fairly Satisfactory	Passed
0 – 7.49	Did Not Meet Expectation	Failed

III. RESULTS AND DISCUSSION

Table 1 Pretest and posttest scores of the participants

Score	PhET Simulation Pretest		PhET Simulation Posttest		Conventional Teaching Pretest		Conventional Teaching Posttest	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**
15	0	0	5	10	0	0	4	8
13 –14	0	0	14	28	0	0	8	16
11 – 12	0	0	18	36	0	0	12	24
9 – 10	3	6	13	26	1	2	21	42
0 – 8	47	94	0	0	49	98	5	10
TOTAL	**50**	**100**	**50**	**100**	**50**	**100**	**50**	**100**
Mean	**5.30 (DNME)**		**11.98 (S)**		**4.84 (DNME)**		**10.88 (S)**	
SD	1.82		1.78		1.85		1.79	
LS	2		9		2		7	
HS	9		15		9		15	

Legend:

Descriptive Rating

O	Outstanding
VS	Very Satisfactory
S	Satisfactory
FS	Fairly Satisfactory
DNME	Did Not Meet Expectation

Table 1 illustrates the pretest and posttest scores of the participants. In the pretest, the PhET simulations group obtained a mean score of 5.30 with a standard deviation of 1.82 while the conventional-teaching group got a mean of 4.84 with a standard deviation of 1.85. The data revealed that both of the groups had almost the same level of understanding about the topic at hand which fell under the category of did not meet expectation. The data also implied that the students in both groups had limited prior knowledge about the topic. Whereas, the posttest scores showed that the PhET simulations obtained a mean score of 11.98 described as satisfactory, an increase of 6.68 from its pretest, with a standard deviation of 1.78 while the conventional teaching group gained 10.88 described as fairly satisfactory, an increase of 6.04 from its pretest, with a standard deviation of 1.79.

The highest percentage of the participants was 36% from the PhET Simulation scored satisfactory while 42% from Conventional teaching scored fairly satisfactory only. In general, the posttest scores conveyed that the performance of the participants in both groups improved. The studies of Linog, Lahoylahoy, and Alguno (2013), and Paras (2014) also found that participants exposed on both methods of teaching (i.e., PhET simulations and conventional-teaching) improved after the treatment.

Table 2 Comparison between the pretest and the posttest of PhET Simulations group and Conventional Teaching group

Variables	Pretest Mean	Posttest Mean	p-value
PhET Simulations	5.30	11.98	0.000**
Conventional Teaching	4.84	10.88	0.000**

** Significant at 1%

Table 2 shows the comparison between pretest and posttest of PhET Simulations group and Conventional Teaching group. PhET simulations group had mean scores of 5.3 and 11.98 for pretest and posttest, respectively. The group obtained a 6.68 increase in their posttest mean score after the treatment. The attained p-value was 0.000 which is less than the 1 percent significance level. This finding reveals that there was a significant difference in the performance in the pretest and posttest of the PhET Simulations group. Posttest is significantly higher than the pretest score.

This affirms the result of the study of Dela Cruz (2015) that the use of PhET simulations increased the performance of the participants after the treatment.

More so, the conventional teaching group obtained mean scores of 4.84 and 10.88 for pretest and posttest, respectively. This group had an increase of 6.04 on their posttest means score after the treatment. The obtained p-value was 0.000 which is less than the 1 percent significance level. This indicates that there was a significant difference in the performance in the pretest and posttest of the conventional teaching group. Posttest is also significantly higher than the pretest score.

The findings confirm the results of the study of Kabigting (2019) that the use of conventional teaching or traditional instruction also improved the performance of the participants.

Table 3 Comparison between the performances of the participants exposed to PhET simulations and Conventional teaching regarding pretest and posttest

Variables	PhET Simulation	Conventional Teaching	p-value
Pretest	5.30	4.84	0.22^{ns}
Posttest	11.98	10.88	0.00^{**}

** is significant at the 0.01 level; not significant (ns)

Table 3 shows the two-sample assuming unequal variances pretests and posttests of PhET simulations and conventional teaching groups. PhET simulation group gained a mean score of 5.3 and the conventional-teaching group was 4.84. The obtained p-value of 0.22 is more than the 1 percent significance level means that there was no significant difference between the pretests of both groups. This result implies that both the PhET simulation and the conventional teaching groups possessed almost the same level on understanding on the linear equations before the treatment.

This result was consistent on the findings of Paras, 2014 on the performance of the experimental and control groups' pretest scores. A mean of 11.98 obtained by PhET simulations was 3.96 higher than of conventional-teaching group on posttests.

The obtained p-value was 0.00 of which is less than the 1 percent significance level confirms that there was a significant difference in the performances in the posttests of both groups. The result shows that the performance of the students exposed to the PhET Simulations performed better as compared to the conventional teaching group.

Posttest results affirm the study of Linog, Lahoylahoy & Alguno (2013) that PhET Simulations group had a considerable increase in the performance as compared to the conventional teaching group. Although both groups gained significantly in their posttest, learning is the best achieved and observed through PhET simulations that addressed misconceptions, visualized concepts and experienced interactive community.

IV. CONCLUSION AND RECOMMENDATIONS

This study intended at determining the effects of interactive simulations in teaching linear equations. Based on the results, the researcher drew the following conclusions. The performance of the participants on both groups have improved after the treatment; more students improved better under PhET simulations. Both groups obtained significant differences between pretests and posttests, and. It was found out that there is no significant difference on PhET Simulations and conventional-teaching groups' pretest scores while there is a significant difference in their posttests scores.

The researcher hereby recommends that teachers must use simulations more often in their class interactions. In case of the absence of simulations in the discussions; teachers should present the lesson in a more technology interactive discussions in teaching math lessons. Furthermore, school administration must introduce PhET simulations to all math teachers as part of their teaching methodology. Future researchers may conduct similar study from other localities or districts focusing on the additional learning areas.

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