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Effectiveness of GeoGebra in Teaching Grade 10 Mathematics

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Abstract *- This study investigated the effectiveness of using GeoGebra in teaching Grade 10 Mathematics. The study involved 66 Grade 10 students. A total of 34 students were in the control group and 32 students in the experimental group. The researcher utilized quasi-experimental design (for the control group and the experimental group). The research used pre-test and post-test approach. The control group was taught using the conventional way while the experimental group was taught using GeoGebra software. The results showed significant difference between the control and the experimental group (t=-4.05, p = 0.0001). The gain score of the respondents showed significant difference (t = -8.28, p<0.0001). The findings of this study would prove teachers the opportunity to use GeoGebra software in their teaching mathematics that will enhance student's performance in mathematics.*

Keywords – Geogebra, Effectiveness, Mathematics

INTRODUCTION

The application of new technology in education is a reform in the twenty-first century. It is a new and advanced teaching mode which is challenging to the conventional teaching mode. The National Council of Teachers of Mathematics (NCTM, 2000) highlighted that technology integration in the teaching and learning of Mathematics is a necessity [1]. Effective teachers optimize the potential of technology to develop students' understanding, stimulate their interest, and increase their competency in mathematics as proved by several studies. Moreover, teachers can provide greater access to mathematics for all students whenever they use technology strategically.

The integration of technology is recognized in the Philippine basic educational system as one of the appropriate tools in teaching mathematics. Technology has become one of the powerful resources of learning. A lot of Mathematics software have been developed to aid the learning and teaching, including GeoGebra, Geometer's Sketchpad, Mathematica among others.

GeoGebra is a software designed for education in secondary schools. The basic idea of the software development was to create a dynamic software that harmonizes geometry, algebra, and calculus. Geogebra is designed for use in schools and educational institutions [2]. Several studies have been carried out on GeoGebra software to study various aspects of learning.

Shadaan and Leong (2013) concluded that software gives teachers and students the opportunity to work through the concepts together through exploring and visualizing [3]. Likewise, Geogebra is an effective tool in assisting both teachers and students in achieving constructivist learning [4]. Meanwhile, Wei, (2010) [5] concluded that utilization of this software promotes active participation among students during class experimentation in which according to Reisa (2010), it is due to their involvement in the process and its appealing feature [6]. Students also show interest and positive attitude when introducing the software in class.

In addition, the study conducted by Vasquez, (2015) provide evidence that the use of GeoGebra in learning geometric transformations increased overall student [7]. Despite the fact that the intervention of the study was very short, meaningful results were obtained both qualitatively and quantitatively. Observations and interviews during the intervention showed

that students were excited and actively involved in their learning. The use of the software promoted student interaction and cooperative learning as students were strongly engaged answering teacher questions and helping each other throughout the activities. Further, student achievement was enhanced overall student participants. Mudaly and Fletcher (2019) found that the use of GeoGebra aided learners successfully in discovering the linear characteristics of graphs with the majority of learners understanding [8]. Likewise, the study of Bhagat and Chang (2015) provides conclusion that there is positive effect of using mathematical learning software such as GeoGebra to the mathematical achievement of students particularly in learning Geometry [9].

OBJECTIVES OF THE STUDY

This study aims to describe and investigate the effect of Geogebra on students' performance in Mathematics.

Specifically, this study also intended to seek the answer for the following:

1. What is the profile of the grade 10 respondents in terms of sex, age, and academic performance?
2. What is the performance of grade 10 students in the control and the experimental groups before the utilization of GeoGebra?
3. What is the performance of grade 10 students in the control and the experimental groups after the utilization of GeoGebra?
4. Is there any significant difference between the pre-test and post-test scores of the students in the control and the experimental groups?
5. Is there a significant difference between the post-test scores of the students in the control and the experimental groups?

Is there a significant difference between the gain score of the students in the control and the experimental groups?

Hypotheses

To establish structure in answering the preceding problems, the purposeful null hypotheses were presented as follows:

1. There is no significant difference between the pre-test and post-test scores of the students in the control and the experimental group.
2. There is no significant difference between the post-test of the students in the control and experimental groups.

MATERIALS AND METHOD

This study aims to determine the level of performance in Mathematics of students through the aid of GeoGebra. This study utilized the quasi-experimental design (for control and experimental groups). Todman and Dugard (2001), cited pre-test-post-test control group designs are well suited to investigating effects of educational innovations and are common in educational research. The pre-test - post-test control design was found most relevant to this study [10]. In the same setup, the researcher wanted to determine any change or improvement in the results of tests. One group was aided with the utilization of GeoGebra (the experimental group). While for the control group, the conventional way of teaching. Random sampling was used to ensure there was no bias. Two sections were selected based on their math class schedule and similarity of the average grade of the class.

In this study, the effect of GeoGebra on the performance was analyzed using inferential statistics. This study was conducted at one secondary school in Laguna, Philippines. Two classes were selected based on the schedule of their math classes and the similarity of the average grade of the class. The researchers administered a pre-test to both groups of students, the control group, and the experimental group to determine their prior knowledge of the topics to be discussed during the duration of the study.

The researchers made an action plan based on the desired learning outcomes of the students anchored in the prescribed curriculum guide. An orientation was given to the two groups of students, regarding the flow of the study. Both the control and the experimental group were taught the same topics. However, a different method of teaching was used. For the control group, the conventional way of teaching was implemented. While for the experimental group an application of technology by using GeoGebra software is used.

The usual math classes were held in both groups of students. For the control group, enhancement exercises were provided through activity sheet, applied the concepts learned during the discussion. The same activity sheet is provided to the experimental group. However, the students used the GeoGebra software while answering the said activity in their smartphones. Those students who do not own smartphones were able to utilize the software through the computer laboratory. In this study, the researchers used a modified pre-test and post-test based on the pre-assessment and summative test of Mathematics Learner's Module of Grade 10 and some textbook in Mathematics 10. The pre-test and post-test consist of 40 items multiple choice test.

There are five topics with their corresponding competencies used in the duration of the study. For the first topic, Cartesian Plane, the following learning competencies are: to plot pairs of numbers in the Cartesian Plane and determine in what quadrant the points are located. For the second topic, Distance Formula, the competencies are: to find the distance between two points using the Distance formulas and graph the two points. For the third topic, Midpoint Formula, the competencies are: to give the midpoint of a line segment using the Midpoint formula and graph the line segment. For the fourth topic, Equation of a Circle, the competencies are: to determine the center and radius of a circle given its equation and vice versa, graph the circle. And for the fifth topic, Polynomial Function, the competencies are: illustrate polynomial function and graph the polynomial function. Duration of 20 meetings was held to accomplished the topics. The exclusive hour was given for the pre-test, for the orientation, for the post-test, and culminating activity. After the retrieval of the pre-test and post-test examinations, the data was checked, computed, tabulated and treated using the SPSS statistical software system.

RESULTS AND DISCUSSION

Table 1 illustrates the profile of the respondents, in terms of their age, sex and performance of Grade 10 students. The age distribution of both the respondents tells that the age is at most of 16 years old. The sex frequency distribution, states that majority in the control group are female. While in the experimental group, male dominates the female respondents. The mathematics performance of the control group reveals that their performance is Fairly Satisfactory to Very Satisfactory level. Fairly Satisfactory ranges from 75-79; Satisfactory 80-84; Very Satisfactory 85-89. And for the experimental group reveals that their performance is Fairly Satisfactory to Very Satisfactory level. Wherein Fairly Satisfactory (75-79) level had the same frequency distribution with Very Satisfactory level (85-89).

Table 1. Frequency, Percentage and Rank Distribution of the Respondents Profile

Profile	Control		Experimental	
	Frequency	Percentage	Frequency	Percentage
Age				
15	7	20.588	5	15.63
16	22	64.706	14	43.75
17	3	8.8235	9	28.13
18	2	5.8824	4	12.5
Total	34	100	32	100
Sex				
Male	13	38.235	18	56.25
Female	21	61.765	14	43.75
Total	34	100	32	100
Performance				
85-89	5	14.706	11	34.38
80-84	9	26.471	10	31.25
75-79	20	58.824	11	34.38
Total	34	100	32	100

The results in Table 2 showed the mean scores of the control group and the experimental group in each of the five topics. The findings indicated that for the Cartesian Plane topic, the control group has a mean score of 4.79, for the experimental group a mean score of 4.31. Both groups have low proficiency level For the topic Distance Formula, the mean score of the control group is 1.68. The experimental group has a mean score of 1.31. A low proficiency levels. As for Midpoint Formula topic, the mean score of the control group is 3.02, for the experimental group a mean score of 2.5. The proficiency level of both the group is low. The topic Equation of a Circle, the control group has a mean score of 2.15 and the experimental group has 2.34 mean score. A low proficiency levels. And for the topic Polynomial Function, the control group has a mean score of 2.38, and the experimental group mean score is 2.28. Both proficiency level is low. This showed that based on the pre-test, students from both groups were at the same level of prior knowledge.

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Table 2. Descriptive Indices on the level of Performance of the Respondents Before the utilization of GeoGebra.

Pre-Test	Mean		Median		Sd	
Topics	Ctrl	Exp	Ctrl	Exp	Ctrl	Exp
Cartesian Plan	4.79	4.31	5	4.5	1.82	2.02
Distance Formula	1.68	1.31	2	1	1.17	1.09
Midpoint Formula	3.02	2.5	3	2	1.22	1.22
Equation of a Circle	2.15	2.34	2	2.5	1.4	1.15
Polynomial Function	2.38	2.28	2	2.5	1.37	1.02

Table 3 shows the difference between the mean scores of the control group and the experimental group on the post-test performance. There was an increase in the students' performance in the following topics: The topic Cartesian Plane, the mean score of the control group is 6.18 and for the experimental group is 7.19. Both groups had an average proficiency level on the topic. For the topic Midpoint Formula a mean score of 4.24 for the control group and 5.03 for the experimental group. In this topic both the group attained an average level of proficiency. And for the topic Polynomial Function, the control group has a mean score of 5.26 and for the experimental group a mean score of 6.31. Both groups attained an average level of proficiency. However, two topics where the level of proficiency for both the group remains the same. The topic of Distance Formula and Equation of a Circle. The mean score of the control group in the topic of Distance formula is 1.94 and for the for the experimental group 1.81. For the topic Equation of a Circle, a mean score of 2.26 for the control group and 2.97 for the experimental group. Based on the post-test result, there was an increase of students' performance on both groups. Students in the experimental group performed better than the control group. This is because of their utilization of GeoGebra software in each topic. Wherein GeoGebra has two components, the first is where to place the algebraic expressions or equations and on the other side is the graphical representations of each expression. GeoGebra provides an effective visual display tool for the students [11].

Table 3. Descriptive Indices on the level of Performance of the Respondents After the utilization of GeoGebra.

Pre-Test	Mean		Median		Sd	
Topics	Ctrl	Exp	Ctrl	Exp	Ctrl	Exp
Cartesian Plan	6.18	7.19	6	7	1.34	1.77
Distance Formula	1.94	1.81	2	4	1.09	1.13
Midpoint Formula	4.24	5.03	4	5	1.23	1.43
Equation of a Circle	2.26	2.97	2	3	1.5	1.27
Polynomial Function	5.26	6.31	5	6.5	1.89	1.51

Table 4 shows the level of performance of the respondents before and after the utilization of GeoGebra per topic. For the topic Cartesian Plane, the mean score of the control group in pre-test is 4.79 (fair), in post-test 6.18 (average). The experimental group mean score in pre-test is 4.31 (needs improvement), in post-test 7.19 (average). The topic Distance formula, mean score of the control group in the pre-test is 1.68 (needs improvement), in the post-test 1.94 (needs improvement). For the experimental group, the mean score of the control group in the pre-test is 1.31 (needs improvement), in post-test 1.81 (needs improvement). Topic Midpoint Formula, the mean score of the control group in pre-test is 3.02 (needs improvement), in the post-test, the mean score is 4.24 (fair). While the experimental group, the mean score in the pre-test is 2.5 (needs improvement) and for the post-test a mean score of 5.03 (fair). For the topic Equation of a Circle, the mean score of the control group in the pre-test is 2.15 (needs improvement) and in the post-test 2.26 (needs improvement). The experimental group, the mean score in the pre-test is 2.34 (fair) and in the post-test mean score is 2.97 (fair). And for the topic Polynomial Function, the mean score of the control group in the pre-test is 2.38 (needs improvement) and in post-test 5.26 (fair). For the experimental group, the mean score in the pre-test is 2.28 (needs improvement) and in the post-test is 6.31(good). Thus, this finding showed that in each topic, there is an increase in performance of the students in both the control and the experimental group.

Table 4. Comparison of Level of Performance of the Respondents Before and After the Utilization of GeoGebra.

Topic (Pre-Test)	Group	Mean	t-value	p-value	Diff
Cartesian Plane	Ctrl Exp	4.79 4.31	1.0174	0.3128	NS
Distance Formula	Ctrl Exp	1.68 1.31	1.303	0.1972	NS
Midpoint Formula	Ctrl Exp	3.02 2.5	1.7645	0.0824	NS
Equation of a Circle	Ctrl Exp	2.15 2.34	-0.622	0.5361	NS
Polynomial Function	Ctrl Exp	2.38 2.28	0.3378	0.7366	NS
Topic (Post-Test)	Group	Mean	t-value	p-value	Diff
Cartesian Plane	Ctrl Exp	6.18 7.19	-2.6308	0.0107	S
Distance Formula	Ctrl Exp	1.94 1.81	0.4487	0.6551	NS
Midpoint Formula	Ctrl Exp	4.24 5.03	-2.522	0.0142	S
Equation of a Circle	Ctrl Exp	2.26 2.97	-2.0571	0.0438	S
Polynomial Function	Ctrl Exp	5.26 6.31	-3.1398	0.0026	S

Table 5 present the test significance between the pre-test and post-test score of the respondents. No significant difference was noted on the students' score in the pre-test (*t=1.48, p=0.1445).* However, a significant difference was revealed in the students' score in the post-test (*t= -4.05, p=0.0001)*. This means that the students from both groups had the same level of prior knowledge, as revealed by the pre-test. In the post-test, the students in the experimental group performed better than in the control group. Particularly, on the three topics: Cartesian Plane, Midpoint Formula, and Polynomial Functions. The utilization of GeoGebra software in the process of learning mathematics proved to be effective. It has a positive impact to enhance students learning and understanding mathematics. Students spatial visualization ability improves [12]. Collaborative learning was manifested during the study. It promotes students conceptual knowledge about a topic in mathematics [13].

Table 5. Test of Significant Difference between the Pre-Test and Post-Test Scores of the Respondents

Assessment	Group	Mean	t-value	p-value	Diff
Pre-Test	Ctrl	13.79	1.48	0.1445	NS
	Exp	12.56			
Post-Test	Ctrl	19.88	-4.05	<0.001	S
	Exp	23.16			

Table 6 shows the significant difference between the gained scores of the students in the control and the experimental group. It can, therefore, be said that integration of GeoGebra software in mathematics instruction enhanced students' performance in Mathematics, That students who belong to the GeoGebra group scored better than students learn with traditional methods. Likewise, a study conducted by Zengin (2017) show that the use of GeoGebra in the learning and teaching process can give a very good impact in improving students' ability [14]. In the same way, a study of Diković (2009) indicate that GeoGebra helps students grasps problem-based and research-based mathematics learning [15]. The development of technology tools increased students' interest to figure out new things. They tend to explore the world of technology to apply in learning mathematics.

Table 6. Test of Significant Difference between the Gained Score of the Respondents

Assessment Difference	Group	Mean	t-value	p-value	Diff
Gain Score	Ctrl	6.09	-8.28	<0.0001	S
	Exp	10.59			

Conclusion and Recommendations

In this study, the effectiveness of utilizing Geogebra in teaching Mathematics 10 was established. Likewise, it was found that utilization of Geogebra is effective in teaching Cartesian Plane, Midpoint Formula, Equation of a Circle, and Polynomial Function but no significant effect on Distance Formula. Teaching and learning mathematics in the 21st century are not expected to be gloomy. There are varieties of product of technology that can be utilized in order to promote active learning among students. With the combination of teacher's creativity and modern technology, the learning of mathematics will be more meaningful. Thus, Mathematics teaching and learning will become holistic. The study provides the following recommendations: 1) Teachers are encouraged the use of technology in the teaching and learning process of Mathematics. 2) School administrators are encouraged the use of GeoGebra by the secondary school teachers in their Mathematics classes. 3) School officials may utilize the result of these study to provide support and training of teachers on the use of GeoGebra in teaching Mathematics in the ASEAN Regions.

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