APPLICATION OF GEOGEBRA SOFTWARE AND STUDENTS' PERFORMANCE IN PLANE GEOMETRY IN SECONDARY SCHOOLS IN DELTA STATE

By

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Abstract

The study examines the application of GeoGebra Software and students' performance in plane geometry in all the five mission secondary schools in Oshimili-South Local Government Area of Delta State. GeoGebra is an interactive geometry, algebra, statistics, and calculus application, intended for teaching and learning mathematics from primary school to university level. It can be used for active and problem oriented teaching that fosters mathematical experiments and discoveries both in the classroom and at home. The study was guided by three specific objectives, three research questions and three null hypotheses. The study is quasi-experimental, using a pre-test / posttest control design. Two schools were selected using purposive sampling and fifty-nine (59) secondary school II (SS2) mathematics students were drawn from the population of three hundred and twenty-four (324) students using intact classes. The classes were divided into two groups experimental and control which consist of 28 students for experimental group and 31 students for control group. The experimental group was taught using GeoGebra while the control group was taught using the conventional method and taught the same topics. The instrument used for the study was a Performance Mathematics Ability Test (PMAT). The reliability coefficient of the instrument was ascertained using Kuder-Richardson (20) and was found to be 0.75. The findings showed that there is a difference in the mean performance scores of secondary school students II who use GeoGebra in learning geometry (M=44.59, SD=4.95) and conventional method (M= 35.9, S.D = 7.169). It was recommended that mathematics teachers should appreciate GeoGebra software and use it in their teaching.

Keywords: GeoGebra application; Gender; ability level.

Introduction

Mathematics is a means of communication and a tool for solving problems in a wide range context (Ekwueme, 2013). In this sense, it can be said that one of the important components of efficient mathematics education is to teach and be able to look at concepts and events in multiple ways. The knowledge of mathematics is important to human beings in problem solving, technological study and providing ways in real situations.

Mathematics application such as GeoGebra was developed to aid teaching and learning of mathematics. The word 'Geo' is taken from Geometry and 'Gebra' derived from Algebra (Geometry + Algebra = GeoGebra). Geometry and algebra are central to mathematics and have been called its "two formal pillars" (Atiyah, 2001). He liken Algebra to be concerned with manipulation in time, and geometry is concerned with space. These are two orthogonal, aspects of the world, and they represent two different points of view in mathematics.

Markus Hohenwarter (2002) created free, open-source dynamic mathematics software (GeoGebra), which is used for both teaching and learning mathematics. Abramovich (2013) defines GeoGebra as a free online application for the study of geometry, algebra, and calculus. This application combines geometry, algebra and calculus into a single,

easy-to-use package for teaching and learning mathematics from elementary to university level. GeoGebra is a new application system that integrates possibilities of both dynamic geometry and computer algebra in one tool for mathematics education (Hohenwarter & Fuchs, 2004). It allows a closer connection between the symbolic manipulation and visualization capabilities and dynamic changeability. The main idea of using GeoGebra in everyday teaching and learning is to provide opportunities for students of different mathematical skills and levels for better understanding of concepts and fostering them to doing mathematics in new attractive ways (Hohenwarter 2007).

Geometry is the study of properties and relations of geometric figures (Surynkova, 2011). Geometry is important for everyone, not only for technicians, designers, architects, builders or civil engineers. We all need good visual imagination in our everyday life. The two and three dimensional shapes which surround us originated from geometry. This branch of mathematics is not popular among students (Surynkova, 2011). Drawings (the results of geometric projections) are sometimes very difficult to understand. For that reason geometric problems must be provided with clear examples.

Teaching and learning of mathematics should be an enjoyable experience for all students and GeoGebra is part of that enjoyment. GeoGebra is used in many ways in the teaching and learning of mathematics such as; displaying and visualization, since it's provide different representations as a construction tool since it has the abilities for constructing shapes and helps in preparing teaching materials, using it as a cooperation, communication and representation tool (Hohenwarter & Fuchs, 2004). For example, as students attempt to show that the area of a triangle is uniquely determined by its base and its altitude, we could start by asking them to construct and play with an arbitrary triangle, identifying a base and the corresponding altitude.. This interactive exploration of triangles will help students recall facts, clarify related concepts, appreciate the underlying mathematical relations, and set the stage for higher levels of reasoning. To make a feasible plan and avoid unnecessary difficulties, students will also need to understand the interrelationships among various elements of a dynamic construction.

It is often claimed by women "that what a man can do a woman do it better" Gender is one of the reason that influence interest. Umoh, (2003) is of the opinion that difficult tasks are usually reversed for the boys while less difficult ones are considered feminine. Gender and ability level (high, average, and low) are factors that influence the readiness of mathematics learning (Unodiaku, 2013).

Therefore, it is in the researcher's interest to know how to make students' understanding of mathematics through the use of GeoGebra to present a new idea and to make connection between the ideas.

Statement of the Problem

In the teaching and learning of geometry, it has been often realized that students still lack the cognitive and process abilities in the total understanding of geometry (Shaddaan and Leong, 2013). Students seem to face a challenge in applying this knowledge to a given task. It is as though something more is required to guide students so that they are able to manipulate geometry properties to truly understand and visualize it. Students are rarely encouraged to study the processes in which concepts and formulas are derived. Instead, the formulas are memorized with the aim of applying them directly, to solve typical exercises (Denbel, 2015). Since it is difficult for students to create the required geometrical constructions, they may

become demotivated in studying geometry. This insufficient feature of a pencil and paper medium causes the tendency in students to construct a limited concept. To supplement the pencil and paper medium in the teaching of geometry for students, GeoGebra was introduced to patches up this insufficiency by providing students to visualize and understand geometry through exploration. Therefore, this study aimed to ascertain the effect of technological tools in teaching and learning of geometrical Mathematics.

Aim and Objectives of the Study

The aim of this study is to examine the application of Geogebra application and students' performance in plane geometry in secondary schools in Oshimili-South Local Government Area of Delta State. The specific objectives are to:

1) determine the performance of students when taught plane geometry using GeoGebra application and conventional method.
2) compare the mean performance of gender on students ability level when taught plane geometry using GeoGebra software and conventional method.
3) investigate the interaction effect among gender, students ability level and the method of instructions in teaching plane geometry

Research Questions

The following research questions were formulated to guide the study

1) What is the mean difference in the performance of students when taught plane geometry using GeoGebra application and conventional method?
2) What is the mean difference in the performance of the male and female students across their ability level?
3) What are the interaction effects among gender, students' ability level and the method of instruction?

Hypotheses

The following hypotheses were formulated for the study at 0.05 probability levels:

1) There is no significant difference between the performance of students taught plane geometry with the use of GeoGebra application and conventional method.
2) There is no significant interaction effect of gender and ability level on the performance of students in plane geometry.
3) There is no significant interaction effect among gender, students' ability levels and methods of instruction.

Methodology

The design for this study is quasi-experimental. The population of this study consists of all missions Senior Secondary Two (SS2) students in the 5 mission schools in Oshimili-South Local Government area of Delta State, with a population of 324. Two mission secondary schools were selected for this study. One of the schools was tagged experimental while the other was tagged control group. The two schools were selected using purposive sampling. From all the arms of S.S.2 students in each of the selected schools, one S.S.2 class was chosen using simple random sampling. All the students in the intact class formed the sample for the study with a total of fifty-nine (59) students. The instrument for the study was a Performance Mathematics Ability Test (PMAT), which included pre-performance test and post-performance test for both the experimental and control group. This test consists of thirty (30) questions which consist of multiple choice objective tests with four options (A, B, C and

D). Reliability of the instrument was ascertained using the Kuder -Richardson (20). A pilot study was carried out in two secondary schools in Oshimili-South Local Government Area of Delta State which are not part of the sample. The reliability coefficient of the instrument was found to be 0.75, and this shows that the internal consistency of the instrument is within the acceptable level. The data from the performance tests were collected and analyzed. The research questions were answered using frequent count, mean and standard deviation. The hypotheses were tested using t-test analysis and ANCOVA at 0.05 level of significance.

Results

Research Question One

What is the mean difference in the performance of students when taught plane geometry using GeoGebra application and conventional method.

Table 1: Mean performance scores and Standard Deviation (S.D) of students

Methods of Instruction	N	Mean	S.D	Mean Difference
GeoGebra	28	44.59	4.95	8.69
Conventional	31	35.9	7.17	
Total	59			

From the table above the mean and standard deviation of students taught plane geometry using GeoGebra application was 44.59 ± 4.95 and those taught using conventional method was 35.9 ± 7.169. The means difference of the two groups was 8.69. This implies that, students taught plane geometry using GeoGebra application perform better than those students taught using conventional method.

Research Question Two

What is the mean difference in the performance of the male and female students across their ability level?

Table 2: Mean performance scores and Standard Deviation (S.D) of male and female students on their ability level

Gender	Ability Level	N	Pre-test Mean	S.D	Post-test Mean	S.D	Mean Gain
Male	High	9	37.21	5.591	54.00	2.353	16.79
	Average	17	31.40	6.555	44.80	4.395	13.40
	Low	4	22.50	11.71	37.50	10.38	15.00
	Total	30	32.79	8.188	47.82	7.422	15.03
Female	High	6	34.50	8.177	51.00	2.138	16.50
	Average	20	36.53	7.230	44.07	5.910	7.53
	Low	3	25.33	2.309	32.00	6.000	6.67
	Total	29	34.62	7.808	44.81	7.483	10.19

Table 2, showed that male students with high ability had a mean gain of 16.79, average ability 13.40 and low ability 15.00. However, female students with high ability had a mean gain of 16.50, average ability 7.53 and low ability 6.67. Generally, the male had a mean

of 15.03, which is higher than the female of 10.19. This implies that male slightly outperform their female counterpart.

Research Question Three

What are the interaction effects among gender, students ability level and the method of instruction?

Table 3: Mean interaction effects among students' gender, ability level and methods of instruction.

GENDER	METHODS	ABILITY LEVEL	N	Pre-test Mean	S.D	Post-test Mean	S.D	Mean Gain
Male	GeoGebra	High	8	37.21	5.591	54.00	2.353	16.79
		Average	6	31.50	9.192	48.00	0.100	16.50
		Low	2	22.5	11.72	37.50	0.000	15.00
		Total	16	36.50	6.044	53.25	3.000	16.75
	Conventional	High	1	15.2	4.340	28.90	0.000	13.70
		Average	11	31.38	6.564	44.31	4.535	12.92
		Low	2	22.50	11.71	37.50	10.376	15.00
		Total	14	29.29	8.550	42.71	6.669	13.41
	Total	High	9	37.21	5.591	54.00	2.353	16.79
		Average	17	31.40	6.555	44.80	4.395	13.40
		Low	4	22.50	11.71	37.50	10.376	15.00
		Total	30	32.79	8.188	47.82	7.422	15.03
Female	GeoGebra	High	5	35.71	8.015	51.43	1.902	15.71
		Average	5	43.60	5.550	47.00	1.414	3.40
		Low	2	21.5	8.200	32.00	5.432	10.50
		Total	12	39.00	7.920	49.58	2.811	10.58
	Conventional	High	1	26.00	0.000	48.00	0.000	22.00
		Average	15	33.00	5.099	42.60	6.802	9.60
		Low	1	25.33	2.309	32.00	6.000	6.67
		Total	17	30.86	5.586	40.71	7.868	9.86
	Total	High	6	34.50	8.177	51.00	2.138	16.50
		Average	20	36.53	7.230	44.07	5.910	7.53
		Low	3	25.33	2.309	32.00	6.000	6.67
		Total	29	34.62	7.808	44.81	7.483	10.19

Table 3, showed that the mean gain score of male students ability level of 16.75, when exposed to GeoGebra application was higher than the male ability level of 13.41 when taught with conventional method. The mean gain score of female students ability level of 10.58 when expose to GeoGebra application was higher than the female ability level of 9.86 when taught with conventional method. Accordingly, in the course of the interaction, the male in respective of their ability level (High, Average and Low) and methods of instruction had a mean gain of 15.00, which is higher than their female counter of 10.19. This implies that male students outperform their female counterpart in respective of their ability level (High, Average and Low) and methods of instruction.

Testing of Hypotheses

The two hypotheses were tested at 0.05 level of significance.

Ho_1: There is no significant difference between the performance of students taught plane geometry with the use of GeoGebra application and conventional method.

Table 4: t-test analysis of students taught with GeoGebra application and conventional method

Group	N	Mean	S.D	df	t-value	Significant
GeoGebra	28	44.59	4.95	**57**	8.317	.000
Conventional	31	35.9	7.17			

Df = Degree of Freedom

From the above table, the result of the analysis of the two groups showed that there was a significant difference between the mean performance score of students in the GeoGebra group (M = 44.59, S.D = 4.95) compared to conventional group (M = 35.9, S.D = 7.17), t (57) = 8.317; p = .000<.05. This implies that, the mean score of the students in GeoGebra group is higher than the result of students in conventional group.

Ho_2: There is no significant interaction effect of gender and ability level on the performance of students in plane geometry.

Table 5: ANCOVA results of performance scores with respect to gender and ability level of students in plane geometry.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision at p<.05
Corrected Model	4984.875[a]	6	830.813	48.135	.000	s
Intercept	1495.439	1	1495.439	86.641	.000	s
Pre_Test	34.057	1	34.057	1.973	.166	ns
Ability	1348.056	2	674.028	39.051	.000	s
Gender	75.189	1	75.189	4.356	.042	s
Ability * Gender	174.914	2	87.457	5.067	.100	ns
Error	897.531	52	17.260			
Total	112069.000	59				
Corrected Total	5882.407	58				

Table 5, showed that there is no significant difference in the mean performance scores of male and female students ability level when taught plane geometry with GeoGebra method and conventional method (F (2, 52) =5.067 with p = .100; P >.05). Therefore, the null hypothesis was accepted at 0.05 level of significant.

Ho_3: There is no significant interaction effect among gender, students' ability levels and methods of instruction.

Table 6: ANCOVA results of performance scores of gender, students ability and methods of instruction.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision at p<.05
Corrected Model	5174.162[a]	12	431.180	28.005	.000	S
Intercept	1081.176	1	1081.176	70.222	.000	S
Pre_Test	17.325	1	17.325	1.125	.294	Ns
Ability	849.698	2	424.849	27.594	.000	S
Gender	47.997	1	47.997	3.117	.084	Ns
Methods	59.695	1	59.695	3.877	.055	Ns
Ability * Gender	78.493	2	39.247	2.549	.089	Ns
Ability * Methods	127.856	2	63.928	4.152	.022	S
Gender * Methods	23.005	1	23.005	1.494	.228	Ns
Ability * Gender * Methods	24.205	2	12.102	.786	.462	Ns
Error	708.245	46	15.397			
Total	112069.000	59				
Corrected Total	5882.407	58				

The ANCOVA result in Table 6 shows that the F-calculated value (F 1, 46 = .786; p>.05). The null hypothesis is accepted. This implies that there is no significant interaction effect among gender, students' ability levels and methods of instruction.

Discussion of Findings

Results on Table 1 showed that GeoGebra application enhances student performance in understanding in plane geometry than those in the conventional group. As the mean in the GeoGebra group is higher than the mean in the conventional group. This study is in line with Ogbonnaya and Chimuka(2014) who indicated that there was a statistical difference in the mean scores of experimental group (GeoGebra method) ($\bar{x}$ = 63.14) and control group (traditional method) ($\bar{x}$ = 52.5). The process of GeoGebra in classroom instruction deals with actions on a computer screen which positively affect students' learning. The findings of this study are consistent with Hollebrand (2003) who revealed that the use of the computer contributed to students' ability to construct explanations about transformation geometry. However, the students in the conventional group seemed to have not developed dynamic understanding of the problem solving skills required to answer questions

Findings in Table 2 revealed that the male with high ability level slightly outperformed the female with high ability level. The male with average ability level outperformed the female with average ability. The mean gain of female with low ability level is lower than the male low ability level. This implies that male slightly outperformed the female with the mean gain of 15.03 ± 6.980 which was higher than the mean gain of the female of 10.19 ± 7.668. This finding is in line with Dickhauser and Meyer (2006) who worked on gender and young children mathematics ability and found that there is a significant association between gender and ability level. The author suggests that students' ability is in favour of the male students.

The finding in Table 3 revealed that males with high and average and low ability performed higher than females of high, average and low ability level when taught with GoeGebra application. Males with high and average and low ability performed higher than females of high, average and low ability level when taught with conventional method. This

finding agrees with Olosunde and Olaleye (2010) who reported that males are more superior to females at all class levels in mathematics ability test.

The result in Table 4, showed that there is a significant difference in the mean performance of students in the two groups. However, his study concur with Ahmad and Rohani (2010) who discovered that the independent-t test comparing the results of the two groups showed that there was a significant difference between mean performance scores of the control group (M=54.7, SD= 15.660) compared to GeoGebra group (M= 65.23, SD= 19.202; $t(51) = 2.259$, $p = .028 < .05$). This finding indicated that students who had learned Coordinate Geometry using GeoGebra was significantly better in their achievement compared to students who underwent the conventional method.

The result in Table 5, showed that there is no significant difference in the mean performance scores of male and female students ability level when taught plane geometry using GeoGebra method and conventional method ($F (2, 52) =5.067$ with $p = .100$; $P >.05$). Therefore, the null hypothesis was accepted at 0.05 level of significant. This is in line with Okon (2003) that gender does not affect students' performance in mathematics ability test. This indicates that the use of GeoGebra helped to elevate students' conceptual and procedural knowledge in the topic of function for both male and female students.

Furthermore, there is no significant interaction effect among gender, students' ability levels and methods of instruction. In other words, the interaction of gender and ability levels, gender and methods, ability levels and methods were all found not significant ($F 1, 46 = .786$; $p>.05$).) as evidenced in Table 6. This concurs with Bello and Abimbola (1997), as cited in Unodiaku (2013), that in Nigeria's educational system, classrooms are arranged in terms of students with high, average and low ability levels, leading to unequal performance. Although the GeoGebra application affects students of medium competence, the level of increase was less than that among students of high and low competence. Generally, the results of this research showed that GeoGebra is suitable for students of all levels of competence.

Conclusion

GeoGebra method of teaching plane geometry enhances students' performance in plane geometry. GeoGebra application motivates students' interest in learning of plane geometry more than the conventional method. Students' performance in mathematics irrespective of gender can be greatly enhanced through the integration of GeoGebra application into mathematics curriculum which will help the students to develop positive attitude towards the learning of mathematics. Cognizance should be taken for both the male and female in each of their ability levels (high, average, and low) in classroom structures.

Recommendations

The following recommendations are made sequel to the findings, from the study:

i. GeoGebra should be fully integrated into Nigeria's education curriculum
ii. The Federal and State Governments, school owners should try as much as possible to provide enough computers for students' usage.
iii. Mathematics teachers should welcome and accept the use of GeoGebra application in the teaching and learning of mathematics in schools. This can be done by constant organization of conferences, seminars and workshops

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