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IMPROVING ACHIEVEMENT IN GEOMETRY THROUGH THE USE OF GEOGEBRA SOFTWARE AMONG SECONDARY SCHOOL STUDENTS IN UDENU LOCAL GOVERNMENT AREA OF ENUGU STATE

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Abstract
This study was aimed at improving achievement in Geometry through the use of GeoGebra software among secondary school students in Udenu Local Government Area of Enugu State. A quasi-experimental**,** non-equivalent control group design was adopted. The population of the study is the 798 senior secondary school two (SS2) students from the 15 government secondary schools in Udenu Local Government Area of Enugu State. A total of 109 students from four intact SSS2 classes were involved in the study. Multistage sampling technique was adopted in the study. Two groups (experimental and control) were used in the study. The experimental group was exposed to GeoGebra software while the control group was taught using the conventional method. A Pre- Geometry Achievement Test was administered at the initial stage of this study and a Post- Geometry Achievement Test was administered after 4 weeks of treatment using GeoGebra software. Instrument used for data collection was Geometry Achievement Test (GAT). The instrument was constructed by the researchers, face validated by three research experts and content validated through table of specification. GAT yielded a reliability coefficient of 0.86 obtained by Kudar-Richardson 20 formula. Research questions were answered using mean and standard deviation. Hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). Findings showed that the group with access to GeoGebra achieved significantly better scores in the Post-GAT as compared to the group which followed the traditional teaching method. The result also showed that the males exposed to the software achieved better than the females in the same group.

This study indicates that GeoGebra is useful in enhancing the teaching and learning of geometry and mathematics in general. It was therefore recommemededamong others that mathematics teachers should adopt the use of computer assisted instruction (CAI)such as GeoGebra software in teaching geometry.

Introduction

The world is experiencing a third wave of social and technology transformation as the society is becoming more oriented to the information and communication technology (ICT). ICT is one of the various factors that are significantly influencing educational success in the educational section. Mangal and Mangal (2010) see ICT as a set of technological tools and resources used to communicate and create, disseminate, store and manage information. Markauskaite (2006) opined that the introduction of computer technology into teaching and learning is a giant stride towards the quality of education. The information dissemination is easily possible through computer technologies in teaching and learning of all subjects in secondary schools particularly mathematics.

Mathematics is the science that deals with quantity and shapes. It is a science that deals with the logic of shape, quantity and arrangement (Elaine 2013). Odili (2006) also sees Mathematics as a body of knowledge, a collection of techniques and methods, and the product of human activity and even as the activity itself. According to Oginni (2013) Mathematics is embraced worldwide as an asset to all knowledge, since it influences all facets of human endeavour. It is therefore needful for the teaching and learning of mathematics to be given serious attention. One of the general purposes of Mathematics is for students to come to appreciate Mathematics (Baki, 2006). And it is impossible to reach this purpose by enumerating formulas one after another; without associating Mathematics with our environment through the use of technology. For example, if we say that the Earth is surrounded with Geometrical shapes, in classes we can have students perceive that Mathematics is a powerful device to understand the world, and have them appreciates mathematics by relating Mathematics and our environment (Guven, 2006). Mathematics has different branches; which geometry is one of them.

Geometry is the branch of Mathematics that deals with shapes and space. Betiku (2000) views geometry as the science of space which describes and relates with shapes. Betiku continued by

stating that basic geometry allows students to determine properties such as the areas and perimeters of two-dimensional shapes, and surface areas and volumes of three-dimensional shapes. The importance of geometry can never be over emphasized since it improves knowledge and provides method of teaching students to think logically (Obi, 2014). The application of geometry helps in understanding of other areas of Mathematics. Odili (2006) pointed out that geometrical interpretations provide useful and initiative understanding of most areas of Mathematics and geometrical techniques provide tools for solving problems in most areas of Mathematics. In support of this, Agwagah (2008) opined that, knowledge of shapes, numbers, and operations on the shapes help to describe and predict things about the world around us. Despite the importance of geometry and its usefulness in everyday life as an aspect of Mathematics, students still perform poorly in mathematics particularly in geometry. This corresponds to WAEC chief examiner's report of (2013 - 2017) where geometry was rated least in the performance of students followed by algebra. This present study aims to address these inadequacies. Also, Okafor (2002) identified poor use of innovative teaching materials as the major factor contributing to poor achievement of students in mathematics in general and geometry in particular. One effective way of bringing a better enhancement to students learning is through the use of technology.

The uses of technology have kindled great interest in Mathematics education. Currently, considerable resources are being expended to connect students to the global network through the implementation. Disessa (2001) have found that while technology makes abstract ideas tangible, teachers can more easily (i) Build upon students' prior knowledge and skills (ii) Emphasize the connections among mathematical concepts (iii) Connect abstractions to real-world settings (iv) Address common misunderstandings (v) Introduce more advanced ideas. However, Agwagah (2001) noted that mathematics teachers in most cases do not use innovative instructional materials in their mathematics classroom, so most of the mathematics concepts are taught abstractly. Eze (2010) therefore stated that instructional materials make abstract ideas concrete and easier to understand.

In addition, instructional materials which create a medium for effective communication of Mathematical ideas and knowledge

using Information and Communication Technology (ICT) were undermined (Agyei &Voogt, 2012). The researchers also added that this was as a result of teachers' inability to use most of the available ICT facilities. Agyei &Voogt further suggest that teachers should embrace the use of ICT facilities in teaching as it stimulates interest and enhances learning. GeoGebra software among others is the ICT facilities, which teachers can use to facilitate learning.

GeoGebra provides a sound platform for mathematics students to learn and solve Mathematical problems of various topics such as linear programming, complex numbers, vectors, probability, discrete mathematics, calculus, statistics, algebra, functions, graphs and geometry. This dynamic Mathematics software program was created by Markus Hohenwater and now has been translated to 40 languages. Users all over the world can freely download this software from the official GeoGebra website at http://www.geogebra.org. GeoGebra helps teachers in the teaching and learning process of mathematics. This is why Gainsburg (2006) viewed GeoGebra as dynamic and interactive mathematical software for geometry, algebra, and calculus. In addition to being a tool to understand a concept, GeoGebra is also used to explain a procedure. The most interesting part of GeoGebra is the online community comprising regular users, who contribute and share their own teaching materials free of charge. However, researches on the effectiveness of integrating GeoGebra in teaching and learning of geometry are still limited.

Components of GeoGebra

Ozofor (2001) highlighted the components (elements) of GeoGebra as follows:

Menus: File; Edit; View; Options; Tools; Window; Help.

Tools: Move; Points; Lines; Loci/Constructions; Polygons; Circles and Circular arcs; Conics; Measurements; transformation; Slider; Visibility; Toolbar Help.

Views: Graphics/ Geometry View: Default view and drawing pad on which geometrical objects are constructed.

Algebra View: Gives algebraic representation of objects.

Spread sheet View: Every cell has a specific name and names of objects match the spread sheet cells.

Input Bar: Gives algebraic command as alternative to the geometrical tools on the toolbar.

These components make the software easy to navigate and explore. GeoGebra is said to have improved students' achievement in geometry and calculus but based on literature available to the researchers at the time of this study there is no empirical evidence to support the fact. However, the effect of GeoGebra on students' achievement in geometry could be moderated by gender.

Gender can be described as the characteristics that define one as male or female. In recent times, gender has always been a variable of discourse in most researches. There has been a general view that male students tend to perform better than the female students. Alio and Harbor-Peter (2000) experimented on the Polya's problem solving techniques and discovered that males have larger achievement than female in mathematics. In another study carried out by Ogbonna (2007), who used the invitation**,** exploration, proposing and Taking Action (IEPT) constructivist instructional approach to show that there is no significant difference between the achievement of male and female students in mathematics. In a similar study, Adekanye (2008) established that females perform better than males in mathematics. Many factors have been reported to be responsible for dominance of male over female in mathematics; these include gender imbalance, task difficulty, cognitive competence, perceived attitude toward female students by their teachers and influence of gender. In the study of geometry, the same situation has been observed in terms of students' gender and achievement. Yang and Chen (2010) found that male perform better than female by exhibiting better spatial abilities. Acho, Imoko and Ajai (2010) found no significant difference in geometry achievement.

Based on the controversies in gender on students' achievement in geometry, there is a need to investigate theeffect of GeoGebra software on students' achievement in geometry as moderated by gender.

Statement of the Problem

Various researches in Mathematics have shown that students' achievement in mathematics examinations is not encouraging. This has been attributed to teaching method, gender differences, strategy employed in teaching of the subject among others. Poor students' achievement in Mathematics has created major worries for Mathematics educators

in Nigeria. This is because the learning of mathematics in secondary schools have significant role towards understanding of science and as well as technological advancement of the country. Despite the importance of geometry and Mathematics in general, achievement in geometry termly and in external examinations as observed by the researchers is far below expectation.

Several attempts have been employed to remedy the situation, but the problems still persist. This problem tends to affect Geometry more than every other branch of mathematics since students avoid questions on Geometry or treat the questions haphazardly. The level of students' grasp of the concept of geometry is necessary for improvement in students' achievement. Although there has been a high-spirited effort to create gender awarenessyet, gender disparity in students' achievement, poor achievement in geometry and mathematics in general still persists. Hence, there is a need to explore more on gender differences in students' achievement in Geometry. Therefore, the problem of the study put in question form is "what is the effect of GeoGebra software on students' achievement in Geometry?"

Research Questions

Below are questions posed for the study:

1. What is the mean achievement scores of students taught Geometry using GeoGebra software and those taught conventionally?
2. What are the mean achievement scores of male and female students in Geometry?
3. What is the interaction effect of teaching method and gender on student's achievement in geometry?

Hypotheses

The following null hypotheses were formulated to guide the study and were tested at 0.05 level of significance.

1. There is no significant difference in the mean achievement scores of students taught Geometry using GeoGebra software and those taught conventionally
2. There is no significant difference in the mean achievement scores of male and female students in geometry
3. The interaction effects of teaching method and gender on student's achievement in Geometryis not significant

Methodology

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Quasi-experimental design was adopted for this study. Specifically, non-equivalent control group design was used. This is because intact classes which are not equivalent will be used for the study. There will be no random assignment of subjects to avoid disorganization of normal class structure. This is to avoid misrepresentation of the set class structure. This design presented diagrammatically thus:

Group	Pre-test	Treatment	Post-test
Experimental Group	0_1	X_1	0_2
Control Group	0_1	X_0	0_2

Figure1: Diagrammatic Representation of the Research Design

Where:

0_1 = Pre-test
X_1 = Treatment (GeoGebra software)
X_0 = Treatment (conventional method)
0_2 = Post-test

The population of the study is the 798 (361 males and 437 females) senior secondary two (SS2) students from 15 government secondary schools in Udenu local government area of Enugu State. The reason for choosing SS2 students for this study was because the students would have completed their first year in senior secondary school and as such were expected to have been exposed to Geometry in Mathematics. Moreover, using senior secondary two (SS2) classes gave the researcher enough time to carry out the treatment without much interruption since it was not a certification class.

A sample of 109 (43 male and 66 female) senior secondary two (SS2) students was used for the study. This sample was obtained based on the total number of students who were found in the various schools selected for the study. Multistage sampling technique was adopted in the study.Purposive sampling technique was used to select schools using the following criteria:

- government co-educational schools

- selected schools must have at least two senior secondary two(SS2) class
- availability of functional computer sets/computer laboratory,
- constant power supply
- Mathematics teachers with basic computer knowledge.
- The mathematics teacher must have at least a degree in B.Sc or B.Ed and a minimum of two years teaching experience

Two schools were involved in the research. Thereafter, two intact classes were randomly selected from each of this school. The four intact classes were randomized and assigned experimental and control groups respectively. The experimental group was taught with GeoGebra software while the control group was taught with the conventional approach. The experimental group comprised 55(21 males and 34 females) students while the control group comprise of 54(22 males and 32 females) students, making a total of 109 students used for the study.

The instrument designed by the researcher was used to collect data for the study. The instrument was Geometry Achievement Test (GAT). The Geometry Achievement Test (GAT) was a 50 item multiple choice objective test with four options lettered A-D. The instrument was based on the senior secondary school Mathematics curriculum content for geometry broken down into scheme. The instrument was structured according to lower order questions based on remembering and understanding of the cognitive domain and higher order questions covering applying, analyzing, evaluating and creating. The GAT was scored out of 100. Each item carried 2 marks.

The GAT was face validated by three experts in Department of Science Education, (one Mathematics expert and two measurement and evaluation experts) all from University of Nigeria, Nsukka. The experts were required to validate the instrument and vet the lesson notes in terms of content relevance, clarity of language, appropriateness and adequacy of the items in measuring what they are supposed to measure, ambiguity and vagueness of expressions. Content validation was done using table of specification. After the validations, independent corrections and suggestions made by the experts were used to restructure the instrument to 50 items.

The instrument upon validation was trail-tested on 30 senior secondary two (SS2) students in community

secondary school, Ezimo Unoin order to establish the reliability co-efficient of the instrument. Students who participated in the trail test had been taught topics in geometry previously. Data generated were used to determine the reliability of the instrument.Kuder Richardson coefficient (K-R_{20}) was used to estimate the internal consistency reliability for GAT. It yielded reliability co-efficient of 0.86. Pre-GAT was administered before the treatment while post-GAT was administered after the treatment.

The data collected were analyzed and interpreted using mean and standard deviation to answer the research questions and analysis of covariance (ANCOVA) to test the hypotheses at 0.05 level of significance. The analysis and interpretation of the data are as follows:

RESULTS

Research Question 1:
What is the mean achievement scores of students taught geometry using GeoGebra software and those taught conventionally?

Table 1:
Mean and Standard deviation of achievement scores of students taught mathematics using GeoGebra software and those taught conventionally.

Group	N	Pre-GAT		Post-GAT		Mean Gain
		$Mean_1$	**S.D**	**$Mean_2$**	**S.D**	
GeoGebra	55	37.93	13.43	62.25	12.56	24.32
Conventional	54	37.41	12.75	48.72	13.40	11.31

The result presented in Table 1 above shows that the students under GeoGebra software had a Pre-GATmean score of 37.93 with a standard deviation of 13.43 and a Post-GATmean of 62.25 with a standard deviation of 12.56. The difference between the Pre-GATand Post-GAT mean for the experimental group was 24.32. The Conventional method had a Pre-GATmean of 37.41 with a standard deviation of 12.75 and a Post-GAT mean of 48.72 with a standard deviation of 13.40. The difference between the Pre-GATand Post-GAT

mean for control group was 11.31. However, for each of the groups, the Post-GAT mean was greater than the Pre-GAT mean, with the students taught geometry under GeoGebra software having the highest mean gain. This result shows that GeoGebra software leads to students' higher achievement in geometry more than the conventional approach. This is an indication that learning strategy has some effects on students' achievement in geometry.

Research Question 2:
What are the mean achievement scores of male and female students in geometry?

Table 2: Mean and Standard deviation of achievement scores of male and female under GeoGebra softwareand conventional method

Gender	N	Pre-GAT		Post- GAT		Mean Gain
		$Mean_1$	S.D	$Mean_2$	S.D	
Male	43	38.21	14.16	56.93	15.60	18.72
Female	66	37.32	12.36	54.65	13.96	17.33

The result presented in Table 2 shows that the male students had a Pre-GAT mean score of 38.21 with a standard deviation of 14.16 and a Post-GAT mean score of 56.93 with a standard deviation of 15.60. The mean gain score for the male group was 18.72. For the females, the Pre-GAT mean was 37.32 with a standard deviation of 12.36 and a Post-GAT mean of 54.65 with a standard deviation of 13.96 the mean gain score was 17.33. The result shows that the male students achieved higher than their female counterparts and therefore shows that gender has some effects on students' achievement in geometry.

Research Question 3:
What is the interaction effect of teaching strategy and gender on student's achievement in geometry?

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Table 3:
Mean and Standard deviation of achievement scores of male and female under GeoGebra software and conventional method

	Gender	N	Pre-GAT		Post- GAT		Mean Gain
			Mean$_1$	**S.D**	**Mean$_2$**	**S.D**	
GeoGebra	Male	21	40.48	15.80	64.67	13.61	24.19
	Female	34	36.35	11.71	60.76	11.82	24.41
	Male	22	36.05	12.37	49.55	13.91	13.50
Conventional	Female	32	38.34	13.12	48.16	13.24	9.82

Result in Table 3 shows that the males in the experimental group had a Pre-GAT mean of 40.48 with a standard deviation of 15.80 and a Post-GAT mean of 64.67 with a standard deviation of 13.61. The difference between the Pre-GAT and Post-GAT mean for male group in the experimental group was 24.19. The males in the control group had a Pre-GAT mean of 36.05 with a standard deviation of 12.37 and a Post-GAT mean of 49.55 with a standard deviation of 13.91. The difference between the Pre-GAT and Post-GAT mean for male group in control group was 13.50. Table 3 also shows that the female students under the experimental group had a Pre-GAT means and standard deviation of 36.35 and 11.71 respectively with a Post-GAT mean and standard deviation of 60.76 and 11.82 respectively. The difference between the Pre-GAT and Post-GAT mean for females in the experimental group was 24.41. However, the females in the control group had a Pre-GAT mean and standard deviation of 38.34 and 13.12 respectively and a Post-GAT mean and standard deviation of 48.16 and 13.24 respectively. The difference between the Pre-GAT and Post-GAT mean for females in the control group was 9.82. Results showed that the mean gain for male and female students under GeoGebra software were higher than that of the students in the control group. This indicates that GeoGebra software and gender interact to affect students' achievement in geometry.

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Hypothesis 1

There is no significant difference in the mean achievement scores of students taught geometry using GeoGebra and those taught conventionally

Table 4: Analysis of Covariance (ANCOVA) of students' Achievement in Geometry

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	17905.842[a]	4	4476.461	91.050	.000
Intercept	6543.243	1	6543.243	133.088	.000
PREGAT	12693.328	1	12693.328	258.180	.000
GROUP	4281.897	1	4281.897	87.093	.000
GENDER	91.920	1	91.920	1.870	.174
GROUP * GENDER	52.795	1	52.795	1.074	.302
Error	5113.130	104	49.165		
Total	359377.000	109			
Corrected Total	23018.972	108			

a. R Squared = .778 (Adjusted R Squared = .769)

The result in Table 4 shows the mean achievement scores of students taught geometry under control and experimental groups, an F-ratio of 87.09was obtained with associated exact probability value of 0.00. Since the associated probability (0.00) was less than 0.05 level of significance, the null hypothesis ($H0_1$) which stated that there is no significant difference in the mean achievement scores of students taught geometry using the GeoGebra software and those taught using the conventional approach is rejected. Thus, inference drawn is that there was a significant difference in the mean achievement scores of students taught geometry using GeoGebra software and those taught using the conventional approach. This seems to indicate that the GeoGebra software is superior to the conventional approach.

Hypothesis 2:

There is no significant difference in the mean achievement scores of male and female students in geometry

Table 4 also shows that in the mean achievement scores of male and female students taught geometry under GeoGebra software and conventional approach, an F-ratio of 1.87was obtained with associated probability value of 0.17. Since the associated probability value (0.17) was greater than 0.05 set as bench mark, the null hypothesis ($H0_2$) which stated that there is no significant difference in the mean achievement scores of male and female students in geometrywas not rejected. Thus, inference drawn is that, male and female students taught under GeoGebra software and conventional approach did not differ significantly in their achievement in geometry. This result showed that gender is not a significant factor affecting students' achievement in geometrywhen taught under GeoGebra software.

Hypothesis 3:

The interaction effects of teaching method and gender on student's achievement in geometry is not significant.

Result in table 4 shows that an F-ratio of 1.07with associated probability value of 0.30was obtained for interaction between teaching method and gender on students' achievement when taught geometry. Since the associated probability value (0.30) was greater than 0.05, the null hypothesis ($H0_3$) was not rejected. Thus, there was no significant interaction effect between teaching method and gender on students' achievement in geometry.

Discussion

A significant difference between the means of the experimental and control group on the Post-GATin favour of the GeoGebra group was observed. The findings showed that computer assisted instruction as a supplement to traditional classroom instruction is more effective than traditional instruction alone. The findings of this study is consistent with the study by Joshua (2007) and Ige and Gbemuga (2011), which found positive impact of utilizing mathematical learning software thus enhancing students learning and understanding. It clearly demonstrates the instructional effectiveness of GeoGebra as compared to the traditional construction tools. This study gives an alternative to the teachers to utilize the GeoGebra Software as a tool in their instructional activities. Students can download this software from the specific websites and use it

from their various homes at almost no cost.

Conclusion

The following conclusions have been made based on the result of the study:

i. that there was a significant difference between the mean achievement scores of students'on the Post-GAT in favour of the GeoGebra software group
ii. that gender is not a significant factor affecting students' achievement in geometry when taught under GeoGebra software
iii. that there is no significant interaction effect between teaching method and gender on students' achievement in geometry

Recommendations

According to the results of this study, the researchers had some recommendations:

1. Teachers should be encouraged to use computer assisted instruction (CAI) as a supplement to traditional classroom instruction.
2. Dynamic Geometry Software (DGS) such as GeoGebra should be used in the classroom as it is found to enhance learning.
3. Specialist teachers should be employed to teach mathematics at the Junior Secondary School level to ensure the use of appropriate teaching methods that will boost students' positive self-concept towards Mathematics so as to pay more attention to problem solving skills for better achievement in the subject.
4. Teachers should provide the male and female students the enabling environment to learn and solve mathematical problems cooperatively in order to maintain equity in mathematics achievement.

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