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GEOGEBRA SOFTWARE: A VERITABLE PEDAGOGICAL TOOL FOR IMPROVING STUDENTS' ACHIEVEMENT IN GEOMETRY

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Abstract
The study investigated the impact of Geogebra Software on students' achievement in geometry. The study was carried out in Owerri Municipal Council of Imo State. The study was a quasi-experimental research type adopting the pre-test post test non-equivalent control design. A sample of 114 senior secondary two (SS II) students was used for the study. The instrument for data collection was researchers made objective test with reliability coefficient of 0.80 determined using Kuder-Richardson (KR_{20}) formula. The experiment group was taught geometry using Geogebra software while the control group was taught using conventional approach. The data generated was analyzed using mean and standard deviation to answer research questions while the hypotheses were tested using ANCOVA statistical tool at 0.05 level of significance. The result of the study revealed that Geogebra software was effective in improving students' achievement in geometry irrespective of gender. Based on the result, it was recommended that Geogebra software should be introduced in secondary schools to enable teachers use them for teaching mathematics.

Keywords: *Geogebra Software, Pedagogical Tool, Achievement, Geometry.*

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Introduction

Technology has gradually penetrated into every aspect of human endeavour especially in education. The application of technology in education has transformed the quality of teaching and learning. According to Pannen (2014), as an integrated component of teaching and learning, digital technology allows learning experiences to become innovative, accelerated, enriched, besides deepening skills acquisition. It has in no small measure influenced teaching and learning and has equally altered the conventional role of both the teacher and learner, a paradigm shift from a teacher-centered to a learner-centered learning environment, hence the emphasis placed on learning rather than teaching (Williams, Charles-Ogan & Adesope, 2017). Preiver (2008) indicated that digital technology use in education has the potential to positively enrich the teaching and learning environments. Teaching and learning with the use of technology has many advantages such as providing greater learning opportunities for students, enhancing students' engagement, and encouraging discovery learning (Roberts, 2012; White, 2012; Bennete, 1999). According to Higgins (2003), one of the goals for integrating ICTs in education is to enhance teaching and learning practices thereby improving quality of education. Technology helps the students to understand the concepts and also improved their attitudes towards the subject (Chang, 2004).

National Council of Teachers of Mathematics (NCTM, 2000) stated that technology is essential in teaching and learning mathematics where it can influence the mathematics that is taught and enhances students' learning. Technology can also help students to furnish their visual images of mathematical ideas, organizing and analyzing data and can compute efficiently and accurately. According to Budai (2011), with the support of technology, schools can provide extensive opportunities for facilitating, supporting and enriching the learning environment and continuously enhance the quality of the teaching-learning process.

The application of technology in education allows the students understand concepts that are being taught through activity based learning. Abdul-Saha, Mohd-Ayub and Ahmad-Tarmizi (2010) reported that the use of technology is useful as a tool to support and transform the teaching and learning process, especially for mathematics. Hollebrands (2007) opined that new learning opportunities are provided in technological environments which potentially help students to engage with different mathematical objects and level of understanding. Grandgener (2008) stated that technology helps students to develop flexibility in their thinking about mathematics and enhances their imagination. NCTM (2000) pointed out that, teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well, such as: graphing, visualizing and computing. Integrating technology in mathematics teaching and learning develops the students' interest, motivates them, removes the abstract perception of students towards mathematics, improves their critical thinking and problem solving abilities. In the teaching and learning of mathematics especially geometry, it is important for students to be able to imagine, construct and understand construction of shapes in order to connect them with related facts (Shadaan & Leong, 2014).

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Geometry as a basic and important branch of mathematics is the study of size, shape and position of 2-dimensional shapes and 3-dimensional figures (Kurumeh, Obarakpo, Odoh & Ikyereve, 2016). Geometry is the study of shapes and spaces and NCTM (2000) sees it as a basic skill. The study of geometry is important and it is studied from the primary stage upwards. Researches are bound indicating the poor state of teaching and learning of mathematics especially geometry. For instance, Battista (1999) and Idiris (2006) indicated that students often fail to develop the visualization and exploration skills required for geometrical concepts, problem-solving skills and geometry reasoning. WAEC Chief Examiners' report (2009) in Achor, Imoko and Jimin (2012) lamented on poor performance of candidates in geometrical aspect of the question and further noted that few candidates attempted questions on geometry. Idiris (2006) opined that the lack of understanding in learning geometry discourages the students which leads to poor performance in the subject. Idiris in Azizu and Din (2016) noted that one of the recommended software to be applied in teaching and learning mathematics is Geogebra which is used for teaching topics related to geometry.

Geogebra is an interactive geometry software offering students and teachers ways to design teaching modules and enable mathematics learning in a meaningful way (Jia Yi & Kwan Eu, 2016). Geogebra is another innovative tool for integrating technology in teaching and learning mathematics (Bhagat & Chang, 2011). Geogebra is a dynamic geometric software which provides active exploration instruction with the help of symbolic links and offers alternative opportunities to users (Hohemwalter, 2006). Geogebra can serve as a potent tool to support students' straight lines and all comic sections. Geogebra can motivate students to explore mathematics, offering opportunities for the development of critical thinking, creativity and help students understand experimental, problem solving involved in learning mathematics. Geogebra offers the following advantages:

- Provide basic features of Computer Algebra System (CAS) to bridge gaps between geometry, algebra and calculus.
- For demonstration and visualization as it can provide different representations.
- As a construction tool it has the abilities for constructing shapes.
- For investigating to discover mathematics and help to create a suitable atmosphere for learning mathematics.
- For preparing the teaching materials as a cooperation, communication and representation tool (Jia Yi & Kan Eu,2016)

Many researchers have reported that the use of Geogebra enhanced students' performance in mathematics, for instance Erlina and Zakaria (2014) reported the effectiveness of Geogebra software in solving problems related to geometry. Zengin, Furkan & Kutluca (2012) in a study using Geogebra reported that learning using Geogebra gives meaningful impact for students who learned in the experimental group. Abdul-Saha, Mohd-Ayub and Ahmad-Tarmizi (2010) discovered that the group who learned using Geogebra had significant better achievement than the group who learned with a traditional approach. Guven (2012) reported that using Geogebra as a teaching tool, the experimental group outperformed the control group not only in academic achievement but also in levels of learning of transformation

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geometry. Williams et al. (2017) reported the worth and usefulness of Geogebra in improving students' achievement in mathematics.

Evidence of the effectiveness of Geogebra on students' achievement have been reported, there is still need to validate the reports through further investigation to determine its benefits towards improving students achievement in geometry at secondary school level.

Statement of the Problem

Geometry is an important aspect of mathematics and students are noted to perform poorly in this all important aspect of mathematics. Supporting this, Kurumeh (2007) noted that fear and hate in mathematics which results to lack of interest and poor achievement in mathematics particularly geometry and mensuration. Also, instructional process applied by mathematics teachers hinders students interest which leads to poor achievement. This makes it pertinent to harness instructional processes that will enhance students' interest and lead to better achievement.

This study was therefore carried out to investigate the impact of Geogebra software as a pedagogical tool on senior secondary school students' achievement in geometry.

Purpose of the Study

The main purpose of this study was to investigate the impact of Geogebra software as a pedagogical tool on improving secondary school students' achievement in geometry. Specifically, the study will determine:

1. Whether students taught geometry using Geogebra software as a pedagogical tool will differ in achievement with those taught conventionally.
2. Gender effect on achievement of students taught geometry using Geogebra software as a pedagogical tool.

Research Questions

The following research questions were raised to guide the study:

1. What is the difference between the mean achievement scores of students taught geometry using Geogebra software as a pedagogical tool and those taught conventionally?
2. What is the difference between the mean achievement scores of male and female students taught geometry using Geogebra software as a pedagogical tool?

Research Hypotheses

The following hypotheses were formulated for the study:

1. There is no significant difference between the mean achievement scores of students taught geometry using Geogebra software as a pedagogical tool and those taught conventionally.
2. There is no significant difference between the mean achievement scores of male and female students taught geometry using Geogebra software as a pedagogical tool.

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Methodology

The study was a quasi-experimental type adopting the pre-test, posttest non-equivalent control design. This design was adopted since it was not possible to carry out randomization of the subjects.

Table 1: Research Design

Group	Test	Treatment	Posttest
Expt. Group	T_1	X_1	T_2
Contr. Group	T_3	X_0	T_4

$T_1, T_{3=Pre\text{-}test,}$ T_2, T_4=Posttest, X_1=treatment, X_0=No treatment

The population of the study comprised all 315 senior secondary two (SS II) students of Alvana Model Secondary School, Alvan Ikoku Federal College of Education, Owerri. The sample of the study consists of one hundred and fourteen (114) SS II students from two intact classes selected for the study. The two intact classes were randomly assigned to experiment and control groups. The control group consists of 55 students, 26 males and 29 females while the experiment group consists of 59 students, 28 males and 31 females. The instrument for data collection was a researcher made 30-item objective test questions titled "Geometry Achievement Test (GAT)". The construction of the instrument was guided by a table of specification. The face and content validity of the instrument was determined by two mathematics teachers and a measurement and evaluation expert. To determine the reliability of the instrument, it was trial tested on 30 students outside the study group but with the same characteristics, Kuder Richardson (KR_{20}) formula was used to analyze their result which gave a reliability coefficient (r) of 0.80. To administer treatment, the two groups were pre-tested to determine their cognitive readiness. After that, the experiment group was taught geometry "Triangles and polygons" by a trained research assistant. The research assistant was trained on the application of Geogebra software (applet) in teaching the concept. The research assistant who is computer Science expert was trained for 1 week, one hour per contact for four days. The Geogebra software (applet) was downloaded from the website www.geogebra.org and networked on computers in the ICT laboratory unit of the school where the students were taught and each of them had access to a computer. The research assistant taught the concept as directed through a detailed lesson plan and the students accessed the lesson through the computers assigned to them while the process was on. The students were allowed to draw different triangles using the Geogebra software and guided through identifying their corresponding properties using the applet. The entire process was monitored by the researcher to ensure that the outlined steps were maintained. The students had time to practice and learn the concepts by manipulating the computers and navigating through the software and interacted with each other and the teacher whenever they encountered any difficult situation. The control group was taught the same concept conventionally by their regular mathematics teacher as outlined on a lesson plan and they didn't have access to Geogebra software. The entire process lasted for 3 weeks after which a posttest was administered to both groups using a rearranged version of the pre-test instrument and marked over 100%. The generated data was analyzed using mean and standard

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deviation to answer research questions while the hypotheses were tested using analysis of covariance (ANCOVA) at 0.05 level of significance.

Result

Research Question 1: What is the difference between the mean achievement scores of students taught geometry using Geogebra software as a pedagogical tool and those taught conventionally?

Table 2: Summary of Students Achievement

Group	N	Test	Mean (x)	SD	Mean gain	Diff.in Mean Ach.
Experiment	59	Post-test	54.44	7.67	21.89	
		Pre-test	32.55	8.16		20.08
Control	55	Post-test	34.23	8.06	1.81	
		Pre-test	32.42	8.14		

Table 2 shows that students taught Geometry using Geogebra software had pre-test mean score of 32.55 with standard deviation of 8.16 and posttest score of 54.44 with standard deviation of 7.67 which gave a difference in mean gain of 21.89 while those taught conventionally had pre-test mean score of 32.42 with standard deviation of 8.14 and posttest mean score of 34.23 with standard deviation of 8.06 and had mean gain of 1.81, these gave a difference in mean achievement score of 20.08 in favour of those taught using Geogebra software.

Research Question 2: What is the difference between the mean achievement scores of male and female students taught geometry using Geogebra software as a pedagogical tool?

Table 3: Summary of Gender Mean Score in Experiment

Gender	N	Test	Mean (x)	SD	Mean gain	Diff. in Mean Ach.
Male	28	Post-test	55.26	7.6	22.04	
		Pre-test	33.42	8.13		0.97
Female	31	Post-test	53.42	7.66	21.07	
		Pre-test	32.35	8.21		

Table 3 shows that male students taught Geometry using Geogebra software had mean sore of 33.42 with standard deviation of 8.13 in pre-test and 55.26 with standard deviation of 7.26 in posttest, these gave a mean gain of 22.04 while their female counterparts had 32.35 with standard deviation of 8.21in pre-test and 53.42 with standard deviation of 7.66 in posttest which gave a mean gain of 21.07. These resulted to a difference of mean gain of 0.97 in favour of the males.

$H0_1$: There is no significant difference between the mean achievement scores of students taught geometry using Geogebra software as a pedagogical tool and those taught conventionally.

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Table 4: Summary of ANCOVA Analysis

Source	Type in sum of squares	df	Mean square	f	Sig.	Remark
Corrected model	15947.940	4	2657.990	37.409	.000	S
Intercept	13110.414	1	13110.414	184.519	.000	S
Covariate	14.785	1	14.785	.208	.649	NS
Method	**15242.930**	**1**	**15242.930**	**214.532**	**.000**	**S**
Gender	**95.648**	**1**	**95.645**	**1.346**	**.249**	**NS**
Method * Sex	25.132	1	25.132	.354	.555	NS
Error	7602.551	109	71.052			
Total	236060.000	114				
Corrected total	23550.491	113				

Table 4 shows that the calculated f-value (214.532) for method is greater than critical value (3.97) and $p > 0.05$ ($F, 113 = 214.532, p < 0.05$). Based on the result, the null hypothesis is rejected and the alternative accepted, which implies that there is a significant difference between the mean achievement scores of students taught geometry using Geogebra software as a pedagogical tool and those taught conventionally.

$H0_2$: There is no significant difference between the mean achievement scores of male and female students taught geometry using Geogebra software as a pedagogical tool.

Table 4 shows that the calculated f-value (1.346) for gender is less than the critical value (3.92) and $P > 0.05$ ($F, 113=1.346$ $P > 0.05$). Based on the result, the null hypothesis is upheld at 0.05 level of significance.

Discussion

The result of the study indicated that students in the experiment group had more achievement gain than those in the control group. This result is further confirmed by the result of table 2 which implies that method is a determining factor in students' achievement in geometry. Further statistical analysis showed that there is a significant difference between the mean achievement scores of students taught geometry using Geogebra software and those taught using conventional approach. The result is consistent with the reports of Elona et al. (2014), Williams et al. (2017), Guven (2012), Shadaan et al. (2014) which illustrated that the students in the experimental group performed better using Geogebra than the control group using the traditional learning method.

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The result of the study also revealed that male and female students in the experiment group had improved achievement with male students having a minor edge over their female counterparts. Further statistical analysis showed that there was no significant difference between the mean achievement scores of male and female students taught geometry using Geogebra software. This is an indication that gender is not a factor in students' achievement in geometry when technology such as Geogebra is applied in teaching and learning. This result is ~~in~~ consistent with the finding of Akanmu (2015) which showed that there is no significant difference between the post-test performance of male and female learners taught mathematics with the use of Geogebra.

Conclusion

Through the result of this study, it was discovered that students exposed to learning geometry using Geogebra software, had improved achievement irrespective of their gender. This is an indication that the use of technology in teaching mathematics enhances students' achievement.

Recommendations

Based on the findings of the study, the following recommendations are made:

1. Geogebra software should be used in teaching mathematics at the secondary school level to enhance students' achievement.
2. Mathematics teachers in secondary schools should be ICT compliant to enable them apply ICT software in teaching mathematics.
3. The Government should organize workshops, conferences, seminars to train mathematics teachers on the use of technology in teaching mathematics.
4. Government and non-governmental organizations should provide computers and accessories to secondary schools to enable teachers and students use them during mathematics classes

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