Effects of Geogebra Software on Secondary Students' Mathematics Performance and Retention in Ogbia LGA, Bayelsa State

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Abstract

The study investigated the effects of GeoGebra Software on Secondary Students' Mathematics performance and retention in Ogbia Local Government Area, Bayelsa State. Pre-test, post-test non-equivalent quasi-experimental design was employed for this study. Two research questions guided the study. Out of a total population of four hundred and fifty (450) Mathematics students in six (6) public secondary schools, a total of one hundred and sixty-three (163) students from three co-educational secondary schools purposively selected formed the sample size of the study. Geometry Performance Test (GPT) which also tested retention with a reliability index of 0.85 was developed. Research questions were answered with mean and standard deviation. The results revealed that GeoGebra Software and Geoboard proved more effective than lecture method in students' understanding of geometry. Furthermore, the study noted that GeoGebra Software is effective learning strategies for enhancement of students' retention in Geometry. It was recommended that GeoGebra Software should be used by Mathematics teachers to teach geometry so as to enhance students' performance and retention in Mathematics.

INTRODUCTION

GeoGebra is a dynamic mathematics software for all levels of education that brings together geometry, algebra, spreadsheets, graphing, statistics and calculus in one engine. In addition, GeoGebra offers an online platform with over 1 million free classroom resources created by our multilingual community. These resources can be easily shared through our collaboration platform GeoGebra Classroom where student progress can be monitored in real time. GeoGebra is a community of millions of users located in just about every country. It has become the leading provider of dynamic mathematics software, supporting science, technology, engineering and mathematics (STEM) education and innovations in teaching and learning worldwide. GeoGebra's math engine powers hundreds of educational websites worldwide in different ways from simple demonstrations to full online assessment systems (Abramovich, 2021).

Due to the relevance of these tools in the society, human actions are largely determined by them. Human life in the society has been greatly enhanced by these tools also called technological resources. These tools have definite potentials to educate the mind and reshape learning capacities. The use of these technological facilities (digital tools or technological resources) has brought efficiency and convenience in the way we teach and learn. To teach more effectively, Ajayi (2020) claimed that teachers need to know more about digital pedagogy, new learning theories and differences in students that are associated with digital tools and activities and have a deeper understanding of variety of learning styles in 21st century. The present-day students are digitally oriented in their environment. The environment they are exposed to is media rich, electronic and digitally connected. This environment provides communication medium with instant gratification. These set of students are called Digital Natives (Mickel, 2021). Teachers are therefore expected to migrate to digital world in order to be relevant in the educational system.

Blended learning is no longer an option for classrooms, it is a necessity. The combination of face-to-face instruction and digital learning opportunities allows for individualization, flexibility and greater chance for students' academic success. The 21st-century learning has changed from traditional method to digital pedagogy. Learning styles which refer to students' approaches to learning, problem solving and processing information are also changing. The way students learn is very important in any teaching-learning situation because if students are to learn content knowledge to facilitate remembering, understanding, applying, analyzing, evaluating and creating, then educators can be assured that teachers are scaffolding learning by building on a basis of knowledge recall and comprehension to desired outcomes and consequences, which would enhance creativity and innovation. Impressively, teaching and learning with the aid of technology in this 21st century have become very prominent amongst the most basic and much-talked-about subjects in present-day education conversation, which is as a result of the fact that the advantages associated with the utilization of technology in aiding teaching and learning glaringly supersede its disadvantages. As such when technological tools are appropriately utilized, there is a high prospect that the outcome of the conversation will be tremendous as compared to when it is not utilized or inappropriately utilized for the same purpose. However, it can be stated that the utilization of technological software in educating learners has had a huge impact on both teachers and learners by way of proving a medium for instructors and learners who collaboratively interact in course of the teaching and learning process.

The Mathematics teaching is use in digital pedagogy. Mathematics is defined as the science that deals with the logic of shape, quality and arrangement. Mathematics is seen today as the mother of all subjects. It is an important subject that is applicable to all facets of life. Everyone in the society makes use of Mathematics on daily basis including market men and women. As a result of this, the role played by Mathematics in all areas of development in live cannot be under-estimated. Mathematics serves as a backbone to all technological advancement in the world. There can be no meaningful development in this modern world of technological era without adequate and sufficient knowledge of Mathematics. The study of Mathematics enhances one's understanding of the world through the use of symbols and abstract representation of phenomena. It is a subject that is very important for the academic excellence of people irrespective of the programme of study. Knowledge of Mathematics is applied in every school subject. In Nigeria, Mathematics is one of the core subjects in the curricula of basic schools, senior secondary schools and colleges of education. Mathematics is all about

logical analysis, deduction, calculation within its pattern and structures. Mathematics is also seen as a science that investigates geometric figures, compute numbers, and study abstract topics such as quantity (numbers), structures, space and change. Mathematics is also seen as the science that deals with the logic of shape, quality and arrangement. Mathematics is all around us, in all we do. It is the building block for all our daily activities including mobile devices, architecture (ancient and modem) art, money, engineering, and even sports. Although, Mathematics has no generally accepted definition, but it can also be described as the study of different topics such as quantity, structure, space and change. Though, through the use of abstraction and logic, Mathematics developed from counting, calculation, measurement and the systematic study of the shapes and motions of physical objects. It is very difficult to imagine a world without Mathematics. Mathematics is featured as one of the most prerequisite for entry into higher institutions. In addition, many Universities having realized the importance of mathematical knowledge and have embedded some mathematical courses in various courses to be studied in the non-Mathematics programme. For instance, students that are supposed to undertake a research work as part of their programmes can only be successful when they have acquired basic knowledge in statistic, a branch of mathematical knowledge.

The importance of Mathematics as a school subject cannot be over-emphasized. Its role as foundation for nation building, utility base for daily living, agent for development of critical and disciplined mindsets in individuals and support-service to other disciplines has been highlighted by many writers (Fitzmaurice, O'Meara, & Johnson, 2021). The United Nations Educational, Scientific and Cultural Organization (UNESCO), in pursuance of its global education for all program recognizes the importance of Mathematics to the educational growth of the child, promotes Mathematics education globally especially in developing countries. Hence it supports activities that address the lack of interest by students in Mathematics and those that aim at enriching teachers on both their knowledge of new developments in mathematics as well as its significance to society. The Mathematics curriculum at the secondary school level is aimed at preparing students to acquire ability to apply scientific knowledge to everyday life and to take a decision for further study at the University level. In other to achieve these objectives, teachers must adopt learner centered instructional strategies that will combine the power of teachers with the power of technology in the classroom like the use of GeoGebra software and Geoboard application in the teaching of Mathematics in secondary schools.

Geogebra is an e-learning package that uses electronic innovations to access educational curriculum outside of a conventional classroom. It provides a platform where the teacher and students play active roles in the teaching and learning process. The software is open-sourced and allows learners to download the product over and over on various computers and from different locations free-of-charge. GeoGebra comes with different language choices where learners can choose the language, they are conversant with. It can be used for problem-solving in key areas of geometry, algebra, calculus, and probability topics. Most interestingly, GeoGebra stands out among the most prevalent software that is generally utilized in teaching and learning of Mathematics branches like Geometry, Algebra, Calculus, and Probability everywhere throughout the world. The utilization of GeoGebra in teaching provides learners with a variety of options and methods of solving problems considered as difficult concepts. Students can carry out calculations 'on the binomial distribution of a data set, as well as create and manipulate the spreadsheet view to graphical view in an intuitive manner. These functions are possible because GeoGebra is best known for its multiple presentations of mathematical

objects. If an object is changed in one window, its presentation in the other window will be quickly refreshed.

The importance of Mathematics in secondary schools in Nigeria cannot be over emphasized. This importance is because of the compulsory position it occupies in the scale of subject's preference during a university admission. Most students actually believe that Mathematics is difficult to understand which has reflected on the underperformance of students in external examinations. This was in line with the 2017 WAEC Chief Examiner's Report for Mathematics which demonstrated that candidates indicated shortcoming, in their failure to work out geometry. Moreover, the Chief Examiner of the West Africa Examination Council (WAEC) report for 2018 May/June West Africa Senior Secondary Certificate Examination (WASSCE) indicated that only 49.98% (comprising 47.32% of male and 52.68% of female) made the minimum of credits in five subjects and above, including Mathematics and English language. The foregoing statistics does not only reveal the abysmal performance of students in mathematics nationwide in terms of the rising percentage of students who obtain a pass and below in Mathematics, but it also indicates that the statistics on the performance of students who obtain credit and above in Mathematics annually rarely surpass an above-average mark. However, this trend requires that urgent steps be taken by the major implementers of the mathematics curriculum to stem the tide of 'mass failure' in the 'all-important subject; mathematics. In this work therefore, the researcher believed that if Geoboard are integrated into the teaching and learning of geometry, the number of students that would obtain the minimum of credits in Mathematics will likely be high considering the university standard.

Disheartening as it may be, to realize that regardless of the various Mathematics software that has the prospects of invigorating and enhancing students' performance and retention in Mathematics, most Mathematics teachers have dominated the classroom with talk-chalk approach of teaching Mathematics and have turned students to mere listeners; students are not urged to examine and communicate with one another and to investigate the introduced concept collaboratively.

Narh-Kert and Sabtiwu (2022) conducted a study on the impart of using GeoGebra in the teaching and learning of Geometry among mathematics education students as well as in-service teachers, using an action research approach. The purposive sampling technique was used to select two public tertiary institutions for the study. The sample size consisted of 150 students comprising 51 from the University of Ghana and 99 from the University of Education, Winneba. Pre- and post- test design, involving teacher-made tests, were used during the experiment to collect data on the samples used. The paired samples t-test and analysis of covariance were used to analyse the scores of tests. The finding showed that there is a statistically significant improvement in the students' scores and interest in the learning, as well as the teaching of Geometry. Also, the GeoGebra method made the lessons more practical and easier to understand. It was therefore recommended that mathematics teachers should incorporate GeoGebra in the teaching and learning of Geometry.

Rabi, Fengqi, Aziz, Ullah and Abduraxmanovna (2021) investigated the impact of students' mathematical representation skills and their attitudes towards GeoGebra. This study was quasi experimental and carried out on high school students. We have two groups belonging to the same standard class. The control group consisted of 22 students, while the experimental group consisted of 28 participants. The conventional approach was used to teach certain concepts of plane geometry to the students in the control group. On the other hand, the experimental group taught similar teachings using GeoGebra. The results show that students have more skills in

mathematical representation using GeoGebra. The semi-empirical test also showed a significant change in students' attitudes between the pre-test and the post-test. Students are more active in mathematical representation skills in GeoGebra.

Uwurukundo et al., (2021). Studied the effect of GeoGebra software on secondary school students' achievement in 3-D geometry in Rwandan. The quasi-experimental design was used, and four schools were purposefully selected. Two schools were from Northern Province, while the other two were selected from Kigali city. A geometry-based test composed of 15 open questions was designed to assess the teaching effect before and after learning geometry. The study was conducted from December 2020 through June 2021 with 87 students. Two schools were assigned as control while the other two as experimental groups. Each group comprised one school from Kigali and one from Northern Province. We analyzed data using SPSS and computed multivariate analysis of variance. We found that students who learned with GeoGebra outperformed those who learned without GeoGebra (M = 77.68% and SD = 14.13 versus M = 56.78% and SD = 15.77, with p < .001 and d = .254). We also found that the number of students who were able to perform each of the 15 questions increased drastically due to the potential of GeoGebra. The study recommends the use of GeoGebra in all teaching and learning activities of mathematics

Lara (2019) investigated the effect of reciprocal peer tutoring strategy assisted by GeoGebra on students' mathematical communication Ability reviewed from gender. The method in this study is the experimental method. The sample was consisted of 72 tenth grade students of SMAN 11. The sample was drawn using simple random sampling technique. The instrument has consisted of prior Mathematics knowledge test and Mathematical communication ability test. Treatment consisted of teaching equations inequalities learning the material to the experimental group using reciprocal peer tutoring strategy assisted by GeoGebra while the control group was taught using expository strategy. The data analysis was done using Analysis of Covariance (ANCOVA). The result showed that (1) reciprocal peer tutoring strategy assisted by GeoGebra affects students' Mathematical communication ability significantly. (2) Gender doesn't affect student's Mathematical communication ability significantly, (3) There is no interaction between strategy (reciprocal peer tutoring strategy assisted by GeoGebra and expository strategy) and gender (male students and female students) on mathematical communication ability.

Abari, (2019) investigated the effect of GeoGebra instructional package on Secondary School Students Retention in Geometry in Makurdi Metropoli of Benue State. Two research questions were asked and answered while two hypotheses were formulated and tested at 0.05 level of significance. The design of the study was quasi-experimental design of pre-test posttest nonequivalent control group. The sample of the study was 205 students. The experimental group was taught using GeoGebra instructional package while the control group was taught using expository method. The instrument for data collection was Geometry Retention Test (GRT) and Geometry Achievement Test (GAT). The data collected at the end of the research was analyzed using descriptive statistics of mean and standard deviation to answer research question, while the hypotheses were tested using analysis of covariance. The result of the study revealed that students taught geometry using GeoGebra instructional package retained higher mean score than those taught using expository method. The result also revealed no significant difference in the mean retention score of male and female students taught geometry, using GeoGebra instructional package.

Charles-Ogan and Gamage (2019) investigated students' perception and performance across ability levels on GeoGebra software usage in learning of Circle Geometry. The study was guided by two research questions and two null hypotheses which were tested at .05 alpha level. Descriptive and quasi-experimental research design was used. A sample of 64 senior secondary two students was selected from a population of 25,913 from the 33 public schools in Yenagoa Local Government Area of Bayelsa State. The purposive sampling technique was employed to select the sample. The instrument used for the collection of data was Geometry Performance Test (GPT) and students' perception on GeoGebra Software (SPGS). A reliability index of 0.82 and 0.63 was established for GPT and SPGS using the test-retest Cronbach methods respectively. The mean, standard deviation, t-test and analysis of covariance were used to analyse the data. The result showed that students had a positive perception on the use of GeoGebra software for the teaching and learning of circle geometry and there was no significant difference between the perception of the male and female students on the use of GeoGebra software for the teaching and learning of circle geometry. The result also revealed that students of all ability levels benefitted from the use of GeoGebra software in the teaching and learning of circle geometry. It was concluded that the use of GeoGebra software to teach circle geometry improved students 'performance of all ability levels and students have a positive perception of the use of GeoGebra software.

Uwurukundo, Maniraho and Tusiime (2021) conducted a comprehensive review of prior literature related to the effects of GeoGebra in enhancing students' attitudes towards geometry. The study employed a systematic review. To collect data, the researcher downloaded journal papers, conference proceedings papers, and theses from different databases such as Google Scholar, Research gate, Academia, Research for life, and Education Resources Information Center (ERIC). Thus, 96 documents were initially obtained. After download, duplicating papers were immediately deleted. Thus, a deep analysis followed and 68 documents were filtered out. Twenty-three documents including 22 journal papers and one thesis remained for analysis. The reviewed literature showed that there are positive effects on students' attitudes towards geometry in terms of interest, engagement and active learning, self-efficacy and self-regulation, and enhanced positive attitudes. More than a half of authors (12 out of 23) employed quasi-experimental research design to investigate the effects of GeoGebra on students' attitudes toward geometry. Considering categories of attitudes identified, the majority of authors (8 out of 23) reported that GeoGebra enhanced students' interest to learn geometry.

Khansila (2022) conducted a study on how to improve academic performance in geometry using a mastery learning approach through GeoGebra for mathematics teacher students and to investigate students' satisfaction with using a mastery learning approach through GeoGebra in geometry. The participants were divided into two groups, involving 30 and 29 students, respectively. The experimental group with 30 students received instruction in the mastery learning approach through GeoGebra, while the control group received a traditional education in learning geometry. At the end of the lessons, post-tests were administered to both groups. The statistical difference between the participant's post-test academic performance in the experimental and control groups was analyzed with an independent sample t-test after examining the assumptions of this test, namely normality and homogeneity in each group, while percentages and means were used to assess the satisfaction of the experimental group. The instruments used were the Geometry Achievement Test (GAT), which consists of 2D and 3D dimensions, and a questionnaire with satisfied students. Results of the study indicated that the scores of academic performances in the experimental group were significantly higher than

those of the control group. Analysis of the questionnaire responses indicated a positive overall satisfaction with using a mastery learning approach through GeoGebra in geometry. On the other hand, instruction with a mastery learning approach through GeoGebra supported students' learning of these subjects meaningfully and conceptually.

This lethargic methodology toward tutoring Mathematics has made numerous students dread and abhor Mathematics. Hence, the focal point of this study is to investigate the effect of Geogebra on secondary students' Mathematics performance and retention in Ogbia Local Government Area of Bayelsa State.

Research Questions

The following research questions guided the study
1. What is the effect of GeoGebra software on students' mean performance score in Mathematics?
2. What is the effect of GeoGebra software on students' mean retention score in Mathematics?

METHODOLOGY

The study adopted pre-test, post-test quasi-experimental design. This is because the study on Geogebra software on secondary students' mathematics performance and retention in Ogbia local government area, Bayelsa state made use of students as respondents. The Students were not randomized. Thus, intact classes were used.

The population of the study consisted of four hundred and fifty (450) senior secondary two (SS2) Mathematics students. One hundred and sixty-three (163) SS1I students (92 males and 71 females) constituted the sample of the study. Purposive sampling technique was used to select three (3) public senior secondary schools while random sampling was used to assigned classes to experimental and control groups. Instrument titled Geometry Performance Test (GPT) was developed and used for data collection by the researcher. The GPT comprised 15 multiple choice objective questions drawn from the content area of study. The test questions were drawn from West African Senior Secondary Certificate Examination past question papers and Mathematics text books for senior secondary school based on the content of the study. The reliability of the instrument was done by test-re-test method. 20 SS2 Mathematics students from a senior secondary school in a neighboring community outside the study sample were used. The test was administered to the students twice over a period of two weeks. The initial and re-test scores were analyzed using Kuder Richardson (KR-20) formula which yielded reliability coefficient of 0.85. The data obtained in this study were analyzed using mean and standard deviation to answer the research questions.

Data presentation and Analysis

Research Question One: What is the effect of GeoGebra software on students' mean performance score in Mathematics?

Table 1: Mean and standard deviation on performance of students in Mathematics using GeoGebra software and lecture method

Group	n	Pre-test		Post-test		Mean Gain	Effect size
		$\overline{X}$	SD	$\overline{X}$	SD		
GeoGebra	57	50.70	3.49	83.06	6.5	42.36	36.22

LM	51	53.06	4.52	59.20	5.6	16.14	

From Table 1, it can be observed that students taught Mathematics using GeoGebra software had a pre-test mean score of 50.70 before treatment while after treatment the post-test mean score was 83.06. For students in the control group who were taught using lecture method, the pre-test mean score was 53.06, while the post-test mean score was 59.20. This result revealed that the mean gain for students in experimental group was 42.36, the control group was 16.14, while the effect size was 36.22. This result indicated that the use GeoGebra software enhanced students' performance in Mathematics than those taught using lecture method.

Research Question Two: What is the effect of GeoGebra software on students' mean retention score in Mathematics?

Table 2: Post-test and retention mean of students in Mathematics with GeoGebra software

Group	n	Post-test	Post Post test	Mean Gain	Effect Size
GeoGebra	57	83.06	90.56	17.5	14.47
LM	51	59.20	62.53	13.03	

According to the result in Table 2, it can be seen that students in the experimental group had a post-test mean score and retention mean score of 83.06 and 90.56 respectively, while those in the control group taught using lecture method (LM) had post-test mean score and retention mean score of 59.20 and 62.53. These values showed that the mean gain for the experimental group was 17.5, the control group was 13.03, while the effect size was 14.47, indicating that GeoGebra software had a positive effect on the retention level of students in Mathematics than the lecture method.

Discussion of Findings
Result in Table 1 and 2 shows that GeoGebra software had a significant effect on students' academic performance and retention when taught Mathematics than the lecture method.
This finding corresponds with Cullen, Hertel and Nickels (2020) whose research findings show significance performance and retention of both sex (male and female) students taught using GeoGebra software.

Conclusion
The study revealed that GeoGebra software enhances students' performance scores and retention in Mathematics (Geometry) than the lecture method.

Recommendations
Based on the findings and the conclusion of the study, the following recommendations were made:
1. Mathematics teachers should be encouraged to adopt GeoGebra software learning strategies to help students develop intellectual capacity that will help in improving their performance.
2. Mathematics teachers should ensure regular usage of hands-on learning strategies such as GeoGebra software which enhances students' retention in Mathematics.

3.   Regular organizing of seminars and workshops for training and retraining of teachers in GeoGebra software strategies should be encourage.

REFERENCES

Abari, M.T. (2019) Effect of GeoGebra package on learning outcomes of Mathematics secondary school students in Ogbomosho North local government area of Oyo State. *Unpublished Master's Thesis*, Obafemi Awolowo University Ile-Ife.

Abramovich, R. (2021). Using dynamic geometry sketchpad to enhance student thinking in geometry. *International Journal of Scientific & Engineering Research*, 6 (4), 11-14.

Ajayi, J.A. (2020). *The effect of blended learning instructional approach on secondary school students' academic achievement in Geography in Akure*, Ondo State, Nigeria.77-86.

Charles-Ogan, G.I. & Gamage, T. (2019). Students 'perception and performance across ability levels on GeoGebra software usage in learning of circle geometry. *International Journal of Statistics and applied Mathematics*, 4(4), 7-11.

Fitzmaurice, O., O'Meara, N. & Johnson, P. (2021). Highlighting the relevance of Mathematics to secondary school students – why and how. *European Journal of STEM Education*, 6(1), 7-16. https://doi.org/10.20897/ejsteme/10895

Khansila, P. (2022). Improving academic performance in geometry using a mastery learning approach through geogebra. *Journal of Educational Issue*. 8(2), 876-894.

Lara, E. (2019). *The effects of using dynamic geometry software in the middle school classroom*. EDT 896 Research Report Iona College.

Mickel, M.E. (2021). *Social science research: Conception, methodology and analysis.* Kampala: Makerere University Press.

Narh-Kert, M. & Sabtiwu, R. (2022). Use of GeoGebra to improve Performance in Geometry. *African Journal of Educational Studies in Mathematics and Sciences* 18(1), 29-36.

Rabi, F., Fengqi, M., Aziz, M., Ullah, M.I. & Abduraxmanovna, N.H. (2021). The impact of the use of GeoGebra on student's mathematical representation skills and attitude. *European Journal of Education Studies*. 8(12), 14-28.

Uwurukundo, M.S., Maniraho, J.F. & Tusiime, M. (2020). GeoGebra integration and effectiveness in the teaching and learning of mathematics in secondary schools: A review of literature. *African Journal of Educational Studies in Mathematics and Sciences*. 16(1), 1-13.

Uwurukundo, N.S., Maniraho, J.F. and Rwibasira, M.T. (2021). Effect of geogebra software on secondary school students' achievement in 3-D geometry. *Education and Information Technologies*. 2(3), 49–57.