GEOGEBRA : THE THIRD MILLENNIUM DEVICE FOR MATHEMATICS INSTRUCTION IN NIGERIA

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Abstract This study aims to investigate the effectiveness of GeoGebra package on learning outcomes of Mathematics students. There is necessity for this research due to the persistent failure recorded by the students in the country, especially at the external examinations like WAEC and NECO. Little or no improvement have been noticed despite numerous recommendations from the past researchers and there was indeed the need to incorporate GeoGebra, an ICT package, into the teaching and learning of Mathematics. This study adopted the non-equivalent pre-test post-test control group design. The study population comprised secondary school Mathematics students in Ogbomoso North L.G.A. of Oyo State, Nigeria. SS II Mathematics students from two intact classes from each of the two purposively selected schools in the area constituted the sample. The schools were selected on the basis of availability of functional computer systems. The classes were assigned into experimental and control groups using simple random sampling technique. The study concluded that the incorporation of GeoGebra and other ICT packages would improve the students' learning outcomes in Mathematics, especially on students' performance in both internal and external examinations; while their attitude towards Mathematics would also be positively enhanced.

Introduction

The teaching and learning of Mathematics in Nigerian secondary schools has recently witnessed a great setback with students performing poorly and showing a lack of interest. This is obvious in their performance in Basic Education Certificate and Senior Secondary Certificate Examinations (check Tables 4 & 5). The problems have been attributed partly to lack of instructional materials especially those involving Information and Communication Technology (ICT). GeoGebra, a new ICT Mathematics software package for teaching Geometry, Algebra and Calculus, has been developed in response to this lack, but its effect on students' learning outcomes such as performance and attitude to Mathematics has not been established. Mathematics is the study of numbers, symbols, counting, measurement, number patterns and relationships of quantities. It involves calculating things in exact, systematic, careful and logical ways. In almost every part of the world, Mathematics

is a compulsory subject in primary and secondary school's curricula. It is indeed the bedrock of sciences and technologies. Nevertheless, according to WAEC Chief Examiner's Report (Nigeria), it has been exposed that students' performance in Mathematics at the senior secondary schools is declining, (check Table 5). The negative students' attitude towards the subject and consequent inconsistence in their performance especially in the West African Senior School Certificate Examination (WASSCE) in Nigeria and the related examinations are of great concern, (check Tables 4 & 5).

Technology aided the development and sustenance of information dissemination, retrieval and use of decision support system. The role of Mathematics for national development, not only in Nigeria but also across the globe is inevitable. For Mathematics to play this role effectively, it has to grow in relation to the global demand and trends. The development of a nation is determined by the nation's technological advancement and this has made technology to become the cornerstone of progress upon which any nation can depend to own self-reliance and self-sustaining growth and development. The idea of a teacher moving from pillar to post in gathering momentum for what to teach his students has been replaced by "on the momentum gathering" through ICT (Ali and Okeke, 2000). GeoGebra, ICT Mathematics software that integrates Geometry, Algebra, Statistics and Calculus has been designed for improved learning outcomes in the subject. GeoGebra is a dynamic, interactive, open-source, student-centred and user friendly package. It has played great roles in incorporating Information and Communication Technology into Mathematics education. As of March, 2008, GeoGebra webpage received about 300,000 visitors per month from 188 different countries. Over 100,000 teachers are already using GeoGebra all over the world for teaching Mathematics and creating static as well as interactive instructional materials to enhance their students' learning, (Preiner, 2008). Mathematics teachers in Austria, Germany, France, U.S.A and Kenya, among others, have inculcated GeoGebra into Mathematics class instruction. The package is currently available in over 44 languages.

Purpose

This study examined the effectiveness of GeoGebra software on the performance of learners in Mathematics. It also investigated the effect of the Information and Communication Technology (ICT) package on students' attitude towards Mathematics in the area. These were with a view to providing information on the effectiveness of the package in improving students' learning outcomes in Mathematics; and a template for integrating ICT into Mathematics class instruction in particular and teachers' education/training program in general.

Hypotheses

The following hypotheses were raised for the study:

H_{01} There is no significant difference between the post-test performance of students taught Mathematics with the use of GeoGebra and the post-test performance of students taught with conventional method.

H_{02} The attitude of students towards Mathematics is not significantly dependent on their knowledge of GeoGebra.

Methodology:

The study adopted the non-equivalent pre-test post-test control group design. The study population comprised secondary school Mathematics students in Ogbomoso North Local Government Area of Oyo State. The senior secondary school two (SS II) Mathematics students from two intact classes from each of the two purposively selected schools in the area constituted the sample (54 students for experimental group and 51 students for control group). Availability of functional computer systems served as basis for selecting the schools. The classes were assigned into two groups (experimental and control) using simple random sampling technique. The experimental group was taught using GeoGebra, while the control group was taught using the conventional method. In experimental group, the students interacted with different kinds of GeoGebra tools to solve problems in geometry, algebra, introductory calculus, among others. The control group was exposed to the conventional method and taught the same topics. The experiment lasted for the period of six weeks. Two instruments were used for data collection, namely Student Achievement Test in Mathematics (SATM) and Mathematics Attitudinal Scale (MAS). The two groups were pre- and post-tested using SATM, after which MAS was also administered to them. Data collected were analyzed using mean and t- test statistics.

Results

From the analysis of data collected before and after the experiment, the following findings were obtained.

Table 1.
Result of t-test of Students' Performance in SATM (Pre-Test)

Group	**N**	$\bar{x}$	**s.d.**	**df**	**α- level**	t_{cal}	t_{tab}	**Decision**
Experimental	54	7.30	2.32					
Control	51	6.41	2.37	103	0.05	1.94	1.98	Insignificant

From the result, the t_{cal} of the pre-test at 0.05 probability level was 1.94 and t_{tab} was 1.98. ($t_{cal} < t_{tab}$), this implied that the differences were not significant and that both groups had the same mathematical background before the commencement of the treatment.

Hypothesis One

Hypothesis one states that there is no significant difference between the post-test performance of students taught Mathematics with the use of GeoGebra and the post-test performance of students taught with conventional method.

To test this hypothesis, the post-test performances of the two groups were compared, and the result is presented in the table below.

Table 2.
The t-test for the Performance of Experimental and Control Groups in SATM (Post-Test)

Group	N	$\bar{x}$	s.d.	df	α-level	t_{cal}	t_{tab}	Decision
Experimental	54	8.19	2.21	103	0.05	5.24	1.98	$H0_1$ is rejected. (Significant)
Control	51	6.29	1.45					

From the table, the calculated value (t_{cal}) was 5.24, with df =103 and at 0.05 probability level, while the critical value (t_{tab}) was 1.98. Since $t_{cal} > t_{tab}$, the null hypothesis thereby rejected. This implied that the experimental group performed better than the control group. By implication, the treatment had some implications on the experimental group on the SATM.

Hypothesis Two

This states that the attitude of students towards Mathematics is significantly independent on their knowledge of GeoGebra. The table below presented the t-test analysis showing whether the attitude of students towards Mathematics is significantly dependent on their knowledge of GeoGebra.

Table 3.
The t-test for the Performance of Experimental and Control Groups in SATM (Post-Test)

Group	N	$\bar{x}$	s.d.	df	α-level	t_{cal}	t_{tab}	Decision
Experimental	54	49.15	6.42	103	0.05	13.58	1.98	$H0_1$ is rejected. (Significant)
Control	51	26.86	9.92					

The table revealed that the calculated value 13.58 is greater than the critical value 1.98 ($t_{cal} > t_{tab}$), the null hypothesis thereby rejected. Thus, the knowledge of GeoGebra positively influenced the attitude of students towards Mathematics.

Discussion

The knowledge of Mathematics has been acknowledged as the great help for the humankind. In one way or the other, everybody must apply the knowledge of Mathematics in his/her day to day activities. Literature pointed out the compulsory status attached to the subject in the school curricula at the primary and secondary levels in almost every part of the world, (Ayeni, 2012; Oluokun, 2010 and Akerele, 2011). The objectives of Mathematics education in the senior secondary schools were also highlighted. However, none of the authors was against the fact that the curriculum must be reviewed from time to time in light of new knowledge, (Olayanju, 2000; NECO, 2011 and WAEC, 2012).

Literature also revealed that the knowledge, skills, attitude, competencies, performance and habits of minds that students are expected to acquire as Mathematics students have been referred to as students' learning outcomes in Mathematics. These are described by what the students are able to demonstrate, represent or produce on

their learning histories, (National Institute for Learning, 2012; Suskie, 2009; Students Affairs, University of Oregon, 2010 and Maki, 2010).

Literature also emphasized that the students' performance in Mathematics between 2006 and 2012 was not encouraging, and further stated that much needed to be done for improved performance of the students, especially at the secondary schools, (see Tables 4 & 5). It was discovered that students' attitude towards Mathematics and sciences are known to decrease as they progress through their schooling years. The submission was also made that attributes such as enthusiasm, respect for students and personality traits would influence students' attitude towards Mathematics and other subjects, (Rufa'i and Adetunji, 2012).

Considering Table 4 below, only 41.12% of those who sat for WAEC 2006 passed Mathematics at credit level. There was improvement in 2007 and 2008 with 46.75% and 57.28% respectively, out of those who sat for the examination in each year, passed the subject at the credit level. However, the performance of the students began to decline from 2009 to 2011 with 46.20% (2009), 41.95% (2010) and 40.35% (2011) of the total number of students that sat for the examination in each year passed the subjects at credit level. The 2012 performance of 50.58% of the total number of students that sat for the examination revealed that the performance was a little bit interesting.

According to the Chief Examiner's Report (Nigeria) in Table 5, majority of students performed poorly in Geometry, while some did not perform well in Algebra and Number & Numeration; since the current curriculum was firstly tested in 2014 there was no report yet on Introductory Calculus as well as other newly included topics (such as Modular Arithmetic, Logical Reasoning and Matrices & Determinant).

Table 4: Performance of Students at WAEC in Mathematics between 2006–2012.

YEAR	TOTAL SAT	CREDIT (A1-C6)	%	PASS (D7-E8)	%	FAIL (F9)	%
2006	1,149,277	472,582	41.12%	357,310	31.09%	319,385	27.79%
2007	1,249,028	583,920	46.75%	333,740	26.72%	331,368	26.53%
2008	1,268,213	726,398	57.28%	302,266	23.83%	239,549	18.89%
2009	1,373,009	634,382	46.20%	344,635	25.10%	393,992	28.70%
2010	1,306,535	548,065	41.95%	363,920	27.85%	394,550	30.20%
2011	1,508,965	608,866	40.35%	474,664	31.46%	425,435	28.19%
2012	1,658,357	838,879	50.58%	478,519	28.86%	340,959	20.56%

Source: Statistics Office, WAEC, Lagos.

Table 5: WAEC Chief Examiner's Report on Mathematics May/June and Nov/Dec, (2012)

Examinations	General Comments	Candidates' Weaknesses	Suggested Remedies
May/ Jun. 2012	The Chief Examiner reported that the standard of the paper as compared with those of the previous years was maintained. The questions	One of the weaknesses observed by the Chief Examiner was candidates' inability to interpret word problems and draw	The following remedies were suggested by the Chief Examiner:

	were reported to be clear, unambiguous and covered a wide area of the syllabus. The diagrams were also reportedly clearly drawn, the marking scheme was well prepared and very lenient to the candidates. The Chief Examiner also reported that though there appeared to be an improvement over that of last year, candidates' performance generally compared to those of the previous years. Their performance in areas of the syllabus such as geometry continued to remain poor.	required diagrams correctly. It was also observed that majority of the candidates did not attempt the question on geometrical construction. Other areas where candidates did not perform very well were: Drawing and reading from graphs Writing answers to the required degree of accuracy Inability to manipulate fractions. Candidates were also encouraged to answer each question on a separate page of the answer booklet.	1.Teachers were encouraged to expose candidates to the application of mathematical concepts to solving problems in their everyday life situations; Teachers as well as candidates were encouraged to cover the syllabus while preparing for the examination; Qualified teachers should be engaged to teach the subject; Teachers were encouraged to use instructional materials during lesson so as to re-enforce the learning of mathematical concepts; Candidates were encouraged to adhere to the rubrics of the question especially with regards to the degree of accuracy; WAEC was encouraged to set questions in these weak areas more regularly in order to encourage teachers and candidates to put in more effort in learning them; Teachers were encouraged to put in more effort at leading the candidates to solving word problems leading to simple algebraic equations.

Nov/ Dev. 2012	The Chief Examiner reported that the standard of WASSCE General Mathematics paper was maintained. The questions covered a wide area of the syllabus and were all drawn from the content of the syllabus. According to the Chief Examiner, the questions were clear, unambiguous and tested a good number of concepts and definitions as well as candidate's ability to apply their principles to solving given problems. The marking scheme was also reported to be well drawn and flexible enough to accommodate all the responses received from the candidates. The Chief Examiner further stated that **candidates' performance compared with those of previous years. According to the report, there appear to be no improvement in the areas of the syllabus where candidates' performance has been observed to be poor** even though there seemed to be an improvement in their performance in other areas.	The Chief Examiner reported that majority of the candidates did not adhere to the rubrics of the paper, especially with regards to approximations and use of tables and calculators. Majority of the candidates were reported to have used calculators in areas where they were restricted from doing so. Majority of them were also reported not to convert from one unit to another correctly. Other areas where candidates' weaknesses were also observed were: 1. word problems; 2. geometrical construction; 3. bearing – representing the given information on a correct diagram; 4. mensuration of plane shapes. Candidates were also encouraged to show all working and write decipherable while attempting the questions.	(1) Candidates were encouraged to learn effectively basic principles and concepts in Mathematics and how to apply them to solving simple everyday problems. (2) Candidates were encouraged to cover the syllabus adequately while preparing for the examinations. (3) Candidates were discouraged from dividing the pages of their answer sheet but should rather begin each question on a fresh page. (4) Candidates were also encouraged to use curly brackets when listing elements of sets. (5) Candidates were encouraged to read through each question carefully in order to understand its rubrics. (6) Candidates should avail themselves past WASSCE question papers while preparing for the examinations.

Source: The West African Examinations Council, Chief Examiner's Report May/June and Nov/Dec, (2012) on CD.

The attention was drawn to some empirical studies on the resources in teaching and learning of Mathematics; audio materials, visual materials and audio-visual materials were highlighted as various instructional materials in teaching – learning process, (Duyilemi, 2009; Salawu, 1999, Oloyede, 2007, Abimbade, 1997 and Kuranga, 1998). On integrating technology into Mathematics education, a lot of computer assisted instructional materials are recommended for the teaching and learning of various topics, since the computerized nature of the global world has led to the intensification of the use of computer in teaching many topics in the subject. The potential that technology offers which include, to help diagnose and address individual needs; to equip students with skills essential for work and life in a 21st century global society, and to provide an active experience for students were stressed. However, the challenges to overcome, and precautions in using technology in teaching and learning of Mathematics were carefully considered by the literature, (Lawless and Pellegrino, 2007; Mainali and Key, 2013; Mapaderun and Raimi, 1998; Moeller and Reitzes, 2011; Olalere, 2013; Bruner, 1961; FME, 2007 and Fadare, 2012).

Literature finally stated that GeoGebra is dynamic Mathematics software that integrates geometry, algebra, statistics and calculus. Short history about GeoGebra, design of GeoGebra, advantages of using GeoGebra and components of the package were fully discussed, (CNET, 2011; Bruner, 1961; Hohenwarter and Preiner, 2007; Ogwel, 2009; GeoGebra Community Newsletter, 2012, 2013; Preiner, 2008; Hohenwarter and Lavicza, 2007, Hohenwarter, 2005; Diković, 2009; Ruthven and Hennessy, 2004). In conclusion, it is evident from the literature that much needed to be done in order to fully integrate GeoGebra and other ICT packages into teaching and learning of Mathematics for improved students' learning outcomes. Ogwel (2009) 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.

Spreadsheet View: Every cell has a specific name and names of objects match the spread sheet cells. See fig. 1.

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

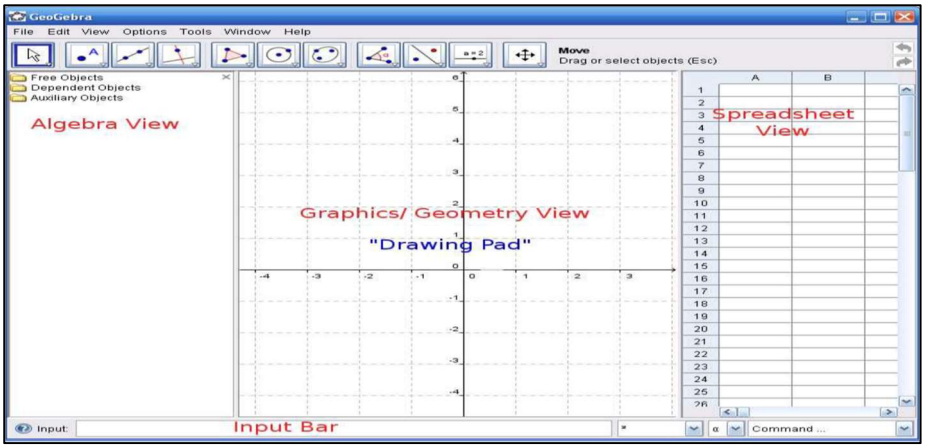

Fig .1. Screen Shot of a GeoGebra Window

Conclusion

This study concluded that students' performance in Mathematics can be greatly enhanced through the integration of GeoGebra software into Mathematics classroom instruction. They can also develop correct attitude towards Mathematics.

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