GEOGEBRA: THE THIRD MILLENNIUM PACKAGE FOR MATHEMATICS INSTRUCTION IN NIGERIA

Akanmu Isaiah Adegoke

Department of Science and Technology Education,
Faculty of Education, Obafemi Awolowo University, Ile-Ife, Nigeria

Corresponding author: Akanmu I. A., akadeg3@gmail.com

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.*

KEYWORDS: GeoGebra, Millennium, Package, Mathematics, Instruction, Nigeria.

1. 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 schools 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 [AO00]). 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, ([Pre08]). According to 2015 analysis, the program developers estimated that the package is available in over 190 countries (*www.community.geogebra.org/it/wp-content.*).
Mathematics teachers in Europe, America and Africa (Kenya in particular), among others, have inculcated GeoGebra into Mathematics class instruction. The package is currently available in over 55 languages.

2. 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 programme in general.

3. 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.

4. 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.

5. 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 was not significant and that both groups had the same mathematical background before the commencement of the treatment.

6. 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.

7. 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.

8. 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, ([Aye12], [Olu10], [Ake11]). 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, ([Ola00], [NEC11], [WAE12]).

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, ([***12b], [Sus09], [***10], [Mak10]).

Literature also emphasized that the students' performance in Mathematics between 2006 and 2014 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, ([Ruf12], [Ade12]).

Considering Table 4 below, only 41.12% of those who sat for WAEC in 2006 passed Mathematics at credit level. There were 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 to 2014 performance of 50.58% (2012), 52.27% (2013) and 61.97% (2014) of the total number of students that sat for the examination each year also revealed the improvement in the performance of the students.

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 Number & Numeration and Algebra. To be specific, they poorly attempted Manipulation of Decimals & Fractions, Geometrical Construction, Graphs, Commercial Arithmetic and Modular Arithmetic.

Table 4: Performance of Students at WAEC in Mathematics between 2006–2014

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
2013	1,658,187	899,901	52.27	463,676	27.96	294,610	17.77
2014	1,632,377	1,011,608	61.97	357,555	21.90	263,214	16.12

Source: Statistics Office, WAEC, Lagos.

Table 5: WAEC Chief Examiner's Report on Mathematics May/June (2012-2014)

Exami-nations	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 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.**	**One of the weaknesses observed by the Chief Examiner was candidates' inability to interpret word problems and draw 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.	The following remedies were suggested by the Chief Examiner: a. Teachers were encouraged to expose candidates to the application of mathematical concepts to solving problems in their everyday life situations; b. 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; c. Teachers were encouraged to use instructional materials during lesson so as to re-enforce the learning of mathematical concepts; d. Candidates were encouraged to adhere to the rubrics of the question especially with regards to the degree of accuracy; **e. 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;** f. Teachers were encouraged to put in more effort at leading the candidates to solving word problems leading to simple algebraic equations.
May/Jun, 2013	The Chief Examiner reported that the standard of the paper compared favourably with those of the previous years. According to the report, the paper had a good coverage of the different sections of the syllabus. The questions were reported to be clear, unambiguous and tested various aspects of the syllabus. The marking scheme was well prepared, detailed and very lenient to the candidates. The Chief Examiner also reported that candidates' performance appeared to have improved when compared to	The Chief Examiner observed that the areas where candidates did not perform very well were: a. Reading and answering problems from graphs b. Writing answers to the required degree of accuracy c. Geometry and its applications d. Mensuration e. Interpretation/solution to word problems f. Drawing required diagrams correctly g. Premature approximation and omission of essential	The following remedies were suggested by the Chief Examiner: a. Teachers were encouraged to expose candidates to the application of mathematical concepts to solving problems in their everyday life situations b. Teachers as well as candidates were encouraged to cover all the topics in the syllabus while preparing for the examination c. Qualified teachers should be engaged to teach the subject d. Teachers were encouraged to use instructional materials during lesson so as to reinforce the learning of mathematical concepts e. Candidates were encouraged to

	that of last year.	details.	adhere to the rubrics of the question especially with regards to the degree of accuracy f. 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 g. Teachers were encouraged to put in more effort at leading the candidates to solving word problems leading to simple algebraic equations h. Candidates were encouraged to answer each question on a separate page of the answer booklet i. Candidates were encouraged to draw diagrams as this would help them in solving problems better j. Teachers should be encouraged to participate in the WASSCE Coordination exercise as well as other training and refresher courses.
May/Jun, 2014	The Chief Examiner reported that the standard of the paper compared favourably with those of the previous years and adequately tested the requisite cognitive and locomotive skills of the candidates. According to the report, not only were the questions well stated and its demands clearly spelt out, the syllabus was also adequately covered and there were no ambiguous questions. Appropriate diagrams were drawn and were clearly labelled. The rubrics were also reported to be clearly stated. The marking scheme was also reported to be well drawn, very comprehensive and generous to the candidates with marks and weighting appropriately distributed on the strength of the question. Candidates' performance was also reported to be slightly better than previous years. However, their performance in those areas of the syllabus where their performance had been reportedly poor has not changed.	The Chief Examiner observed that majority of the candidates exhibited significant weakness in translating word problems to mathematical expressions and diagrams. The report also stated that majority of the candidates did not adhere to the rubrics of the question especially with regards to the use of calculators and Mathematical tables. Some areas of the syllabus that were also reported to be poorly attempted by majority of the candidates included: • Geometry – circle theorems and angles on parallel lines. • Modulo Arithmetic • Commercial Arithmetic • Manipulation of decimals and fractions • Reading and answering questions from graphs. • Representation of information in diagrams.	a. Candidates should be led to do simple arithmetic without the use of calculators and tables. b. Candidates should be encouraged to read the questions carefully so as to understand its demand before attempting them. c. Candidates should be led to acquire knowledge of various Mathematical concepts and how to apply them to solving problems in everyday living. d. Teachers as well as candidates were encouraged to put in more effort to the teaching and learning of geometry and trigonometry. e. Teachers as well as candidates were encouraged to cover the syllabus while preparing for the examination f. Teachers were encouraged to participate in the WASSCE main coordination as this would help them improve on their teaching skills. g. g. Qualified Mathematics teachers should be engaged to teach the subject.

Source: [WAE12]

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, ([Duy09], [Sal99], [Olo07], [Abi97], [Kur98]). 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 computerised 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, ([LP07], [MK13], [MR98], [MR11], [Ola13], [Bru61], [***07], [Fad12]).

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, ([CNE11], [Bru61], [HP07], [Ogw09], [***12a], [***13a], [Pre08], [HL07], [Hoh05], [Dik09], [RHB04]). 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 ([Ogw09]) 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.

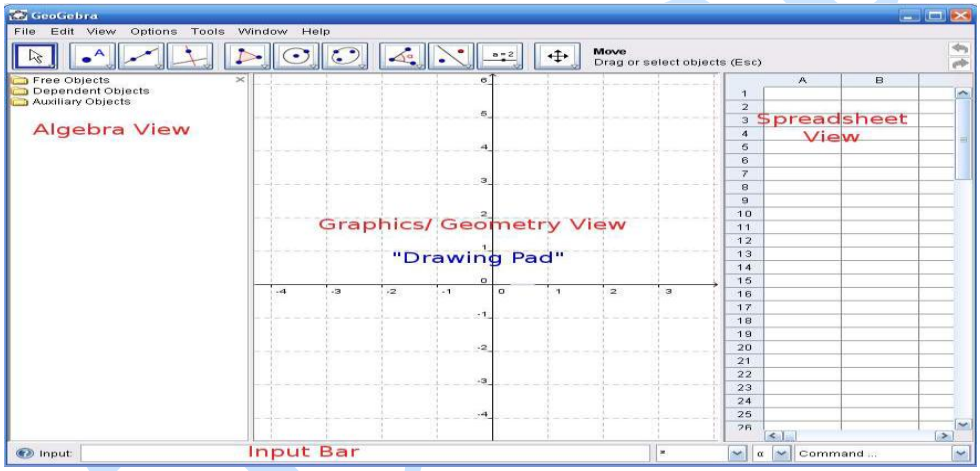

Figure 1. Screen Shot of a GeoGebra Window

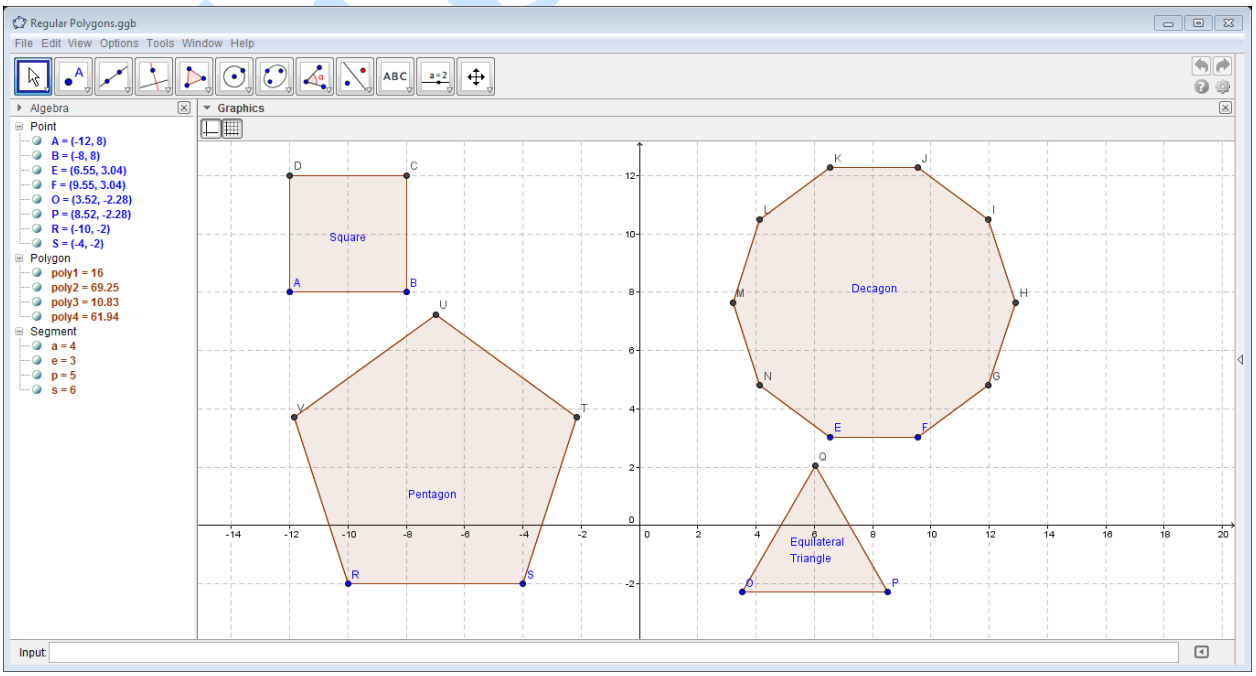

Figure 2. Regular Polygons

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.

REFERENCES

[Abi97] **A. Abimbade** - *Principles and Practice of Educational Technology*. Ibadan: International Publication Limited, 11 – 12, 1997.

[Ade12] **A. A. Adetunji** - *Effects of Historical Simulation and Role Play as Advance Organizers on Osun State Junior Secondary School Students Learning Outcomes*. An Unpublished Thesis of Obafemi Awolowo University, Ile – Ife, 2012.

[Ake11] **O. A. Akerele** - *Factors Militating Against Students' Performance in Mathematics in Secondary Schools*. A Paper Presented in a 3-day Seminar for Mathematics Teachers in Oyo State Public Secondary Schools. April 18 – 20, at Jogor Centre, Liberty Road, Ibadan, 2011.

[Aye12] **R. O. Ayeni** - *The Quest for Development: Why Mathematics Matters*. The 9th Inaugural Lecture Series, LAUTECH, Ogbomoso, Thursday, 20/09/2012, 6 – 16.

[AO00] **A. Ali, E. Okeke** - *Information Technology and Education*. Institute of Education, University of Nigeria, Nsukka: Enugu City Press Ltd., 2000.

[Bal13] **K. Balazs** - *GeoGebra Enabled Mathematics Curriculum. A Future Perspective*. India: NCERT. Retrieved from *http//:www.blog.geogebra.org/author/balazs*, 2013.

[Bru61] **J. Bruner** - *The Act of Discovery*. Harvard Educational Review, 31, 21 – 32, 1961.

[CNE11] **CNET** - *GeoGebra - Free Download and Software Review*, July, 05, 2011. Retrieved from *CNET download.com*, 2011.

[Dik09] **L. Diković** - *Applications GeoGebra into Teaching Some Topics of Mathematics at the College Level*. Computer Science and Information Systems, Vol. 6, No. 2, 191-203. Retrieved from *http:/www.comsis.org/php.show*, 2009.

[Duy09] **A. N. Duyilemi** - *Basic Principles of Curriculum and Instruction*. Ado-Ekiti: Tomol Ltd, 52 - 57, 2009.

[Fad12] **A. O. Fadare** - *Improving the Teaching and Learning of Mathematics through Improvisation of Instructional Resources in a Period of Economic Downturn in Nigeria*. In Oyo State Journal of Mathematical Association of Nigeria (OSJMAN), August, 2012, 3 (2), 67-77.

[Fal12] **A. Falade** - *Foreword*. In Nigerian Principal: Journal of ANCOPSS (NATIONAL). 55th Edition, pp. ii, 2012.

[Hoh05] **M. Hohenwarter** - *Dynamische Mathematikmit GeoGebra 2.5*.Lehrer Online, 2005.

[HL07] **M. Hohenwarter, Z. Lavicza** - *Mathematics Teacher Development with ICT: Towards an International GeoGebra Institute*. In Küchemann, D. (Ed.) - *Proceedings of the British Society for Research into Learning Mathematics*, Volume 27, 49 - 54, University of Northampton, UK. BSRLM, 2007.

[HP07] **M. Hohenwarter, J. Preiner** - *Dynamic Mathematics with GeoGebra*. The Journal of Online Mathematics and its Applications, Volume 7, 2007.

[Kra13] **C. Kravitz** - *Why Mathematics Is Important*. Retrieved on 10th July 2013 from *www.slideshare.net/chelsea kravitz/why-math-is-important*, 2013.

[Kur98] **A. G. Kuranga** - *Resources Materials: The Contemporary Challenges to the Teaching and Learning Process*. A Paper Presented at the 21st National

Conference of the School of Arts and Social Sciences, Kwara State College of Education Oro, held between 25th and 27th November, 1998.

[LP07] **K. A. Lawless, J. W. Pellegrino** - *Professional Development in Integrating Technology into Teaching and Learning: Knowns, Unknowns, and Ways to Pursue Better Questions and Answers*. Review of Educational Research, 77, 575-614, 2007.

[Mak10] **P. L. Maki** - *Assessing for Learning: Building A Sustainable Commitment Across The Institution (2nd ed.)*. Sterling, VA: Stylus, 2010.

[MK13] **B. Mainali, M. Key** - *Using Dynamic Geometry Software GeoGebra in Developing Countries: A Case Study of Impressions of Mathematics Teachers in Nepal*, 2013.

[MR98] **F. Mapaderun, S. Raimi** - *Science and Technology in the Service of Man*. In Abimbola, K. et al (eds). *Citizenship and Computer Education*. Oyo: Andrian Publication Series. p. 167 - 176, 1998.

[MR11] **B. Moeller, T. Reitzes** - *Integrating Technology with Student-Centered Learning*. The Education Development Center, Inc. (EDC). Quincy, MA: Nellie Mae Education Foundation, 2011.

[NCT00] **NCTM** - *Principles and Standards for School Mathematics*. Reston, Virginia: National Council of Teachers of Mathematics, 2000.

[NEC11] **NECO** - *Regulations and Syllabus for SSCE* (General Mathematics), Revised Edition, 35 - 49, 2011.

[Obi07] **G. Obioma** - *Federal Ministry of Education Senior Secondary Education Curriculum: Mathematics for SS 1 – 3 (Preface)*. Abuja: NERDC, 2007.

[Ogw09] **A. Ogwel** - *Using GeoGebra in Secondary School Mathematics Teaching Towards Enhancing Higher Order Thinking Skills*. A paper presented at ICT in the Classroom Conference, by Centre for Mathematics, Science and Technology Education in Africa on Durban Girls' College, Kenya, 24-26 September, 2009.

[Ola00] **O. Olayanju** - *Mathematics Methods II*. In Ayelaagbe, J.A. (ed.), *Teaching Methods*. Ibadan: Oyscoed Publication Series, 133-152, 2000.

[Ola13] **J. O. Olalere** - *Capacity Building for School Personnel through Curriculum Development and Teaching*. A Lecture Delivered during The Annual Conference of Ogbomoso Baptist Conference Teachers' Fellowship Held on Saturday, 24th august, 2013.

[Olo07] **E. O. Oloyede** - *Mathematics Instructional Methods and Materials in the Classroom*. Ile–Ife: Obafemi Awolowo University Press Ltd, 56 – 79, 2007.

[Olu10] **O. Oluokun** - *Using Evaluation to Improve Teaching and Learning of Mathematics*. In Capacity Building Workshop Training Manual for Junior Secondary School Teachers in Oyo State. Oyo, Odumatt Press, 217-223, 2010.

[Pre08] **J. Preiner** - *Introducing Dynamic Mathematics Software to Mathematics Teachers: The Case of GeoGebra*.PhD Dissertation in Mathematics Education. Faculty of Natural Sciences, University of Salzburg, Austria, 35 – 39, 2008.

[Ruf12] **R. A. Rufa'I** - *Nigeria: FG Laments Poor Performance of Students in Mathematics*. Daily champion, 2 March 2012. Retrieved from http://allafrica.com/stories/html, 2012.

[RHB04] **K. Ruthven, S. Hennessy, S. Brindley** - *Teacher Representations of the Successful Use of Computer-Based Tools and Resources In Secondary-School English, Mathematics And Science*. Teaching and Teacher Education, Volume 20, Issue 3, 259-275. Retrieved from *www.educ.cam.ac.uk/people/staff/rut*, 2004.

[Sal99] **I. O. Salawu** - *Introduction to Teaching Aids*. In Mobolaji Ogunsanya (ed.). *Basic Processes in Education*. Ibadan: Andrian Publication Series, 193-204, 1999.

[Sus09] **L. Suskie** - *Assessing Student Learning: A Common Sense Guide Paperback*, in Students Affairs, University of Oregon (2009).

[WAE05] **WAEC** - *Chief Examiner's Report (2005)*.Nigeria: Lucky Star Ent, 237 – 246, 2005.

[WAE12] **WAEC** - *Chief Examiner's Report (2009 - 2012)*. Sidmach Technologies (Nigeria) Limited. On CD, 2012.

[WAE15] **WAEC** - *General Mathematics (Core) Syllabus*. Sidmach Technologies (Nigeria) Limited. On CD, 2015.

[***04] *** - Federal Ministry of Education. *National Policy on Education*. Lagos, 2004.

[***07] *** - Federal Ministry of Education. *Senior Secondary Education Curriculum: Mathematics for SS 1 – 3*. Abuja: NERDC. 2007.

[***10] *** - Students Affairs, University of Oregon (2010). *Students Learning Outcomes: To Transform and Advance Students Learning*. Retrieved on 07/11/2014.

[***12a] *** - GeoGebra Community Newsletter. *GeoGebra*. Retrieved from *GeoGebrawiki, july 2012*.

[***12b] *** - National Institute for Learning Outcomes Assessment.*Making Learning Outcomes Usable and Transparent.* Retrieved from *http://learningoutcomesassessment.org/websiteoverview.html on 07/11/2014*, 2012.

[***13a] *** - GeoGebra Community Newsletter. *GeoGebra*. Retrieved from *GeoGebrawiki, april 2013.*

[***13b] *** - International GeoGebra Institute. *GeoGebra, Mathematics and Science for Learning and Teaching*, 2013.

[***14] *** - Mathematics Department. *Students Learning Outcomes*. University of Wyoming Publication. Retrieved from http://www.uwyo.edu/math/student-learning-outcomes on 07/11/2014.