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ISSUES AND CHALLENGES IN THE USE OF GEOGEBRA IN TEACHING AND LEARNING OF MATHEMATICS IN SECONDARY SCHOOLS IN MAKURDI METROPOLIS

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Abstract:-

This research work examined the issues and challenges in the use of GeoGebra in teaching and learning of Mathematics in Secondary Schools in Makurdi metropolis. Survey research design was adopted for the study. The population of 190 students and 10 teachers were used as respondents for the study. The researcher used both primary and secondary sources obtained by the use of a well-structured questionnaire. The data collected were analyzed using descriptive statistics such as frequency, simple percentages. Confirmatory factor analysis was used for to test the validity of the instrument while the Cronbach Alpha Coefficient was used to establish the reliability of the instrument. The result of the study showed that unavailability or no computer is the major challenges preventing teaching and learning of Mathematics in the selected Secondary Schools in the study area this is followed by low teacher competence as one of the challenges preventing the use of GeoGebra in the teaching and learning of Mathematics in the selected Secondary Schools in the study area. Unavailability of GeoGebra software and erratic power supply are some of the factors. It was concluded that with the availability of dynamic mathematics software, like GeoGebra, teachers will be able to make graphical representations of mathematics concepts and thus present difficult concepts in a very clear and unambiguous manner. It was recommended among others that Policy makers and school authorities should consider the acquisition of computer and GeoGebra software so that they can improve on the level of comprehension of mathematics being taught in school.

Keywords:- *GeoGebra, Teaching, Learning, Mathematics, Secondary, Schools, Benue, Nigeria.*

1.0 INTRODUCTION

GeoGebra is a community-supported open source mathematics learning environment that integrates multiple dynamic representations, various domains of mathematics, and a rich variety of computational utilities for modeling and simulations. Invented in the early 2000s, the aim of GeoGebra was to implement in a web-friendly manner the research-based findings related to mathematical understanding and proficiency as well as their implications for mathematics teaching and learning. The teachers assumed subject matter competence is important for student access to this software. According to Bu and Schoen (2011) a mathematically competent person has the ability of coordinating various representations of a mathematical idea in a dynamic way in order to further gain insight into the focal mathematical structure. In the fields of learning sciences and instructional design there has been several highlights by researchers on the theoretical and practical implications of *mental models* and *conceptual models* involving complex human learning (Milrad, *et al*, 2003) accordingly, Geo Gebra's ability to enhance visualization in Geometry supports this position.

According to Battista (2001); Geometry is a complex interconnected network of concepts, ways of reasoning, and representation systems that is used to conceptualize and analyze physical and imagined spatial environments (Battista 2001). Geometry is also defined as a branch of Mathematics that is concerned with shapes, sizes, relative position of figures and the properties of space. Geometry is the branch of mathematics concerned with lengths, areas and volumes (En.wikipedia.org/wiki/geometry).

Geometrical definitions have to do with space and shape. Hence when defining a geometrical shape, properties such as angles and measurements are used. Effective teaching of Geometry is aimed at enhancing learners' spatial abilities. According to (Battista, 1990) "underlying most geometric thought is spatial reasoning which is the ability to see, inspect and reflect on spatial objects, images, relationships and transformations". In the process of teaching topics and concepts involving Geometry, the teacher expects his/her students to be able to visualize figures, shapes and planes that many not be very obvious to the student. This concept is what makes geometry unique and challenging to learn and teach. GeoGebra promises to alleviate this complication when used knowledgeably. Complications experienced in teaching and learning of Geometry as cited in the second handbook of research on mathematics teaching and learning (Battista 2007).

The West Africa Examination Council (WAEC) Examiners 2011, 2012, 2013, 2014, and 2015 consistently reported candidates' lack of skill in answering almost all the questions asked in General Mathematics and poor performance specifically in Geometry themes like circles and 3- dimensional problems and Algebra. Researchers like Okereke (2006) attributed students' poor performance to factors such as the society viewing Mathematics is difficult, lack of Mathematics laboratory, lack of adequate and qualified teachers and poor teaching methods. The WAEC Chief Examiner's Report (2005) suggested that students' performance in mathematics could be improved through meaningful and proper teaching strategies. The integration of the Computer in the classroom especially with Mathematics software like GeoGebra could enable students to produce quick calculations and assist them in abstracting Mathematical concepts. Teaching and learning of Mathematics with the use of computer has many advantages such as providing greater learning opportunities for students (Roberts, 2012); enhancing students engagement (White, 2012a), and encouraging discovery learning. GeoGebra is a Dynamic Mathematics Software (DMS) developed by Markus Hohenwarter in 2002 for teaching and learning Mathematics which combines many aspects of different mathematical packages (Hohenwarter, 2006, 2010). GeoGebra dynamically joins Geometry, Algebra and Calculus offering these features in a fully connected software environment (Hohenwarter and Lavicza, 2007). The most noticeable feature of GeoGebra is that of multiple representations. It offers two representations of every object: every expression in the algebra window corresponds to an object in the geometry window and vice versa providing a deeper insight in the relations between geometry and Algebra (Hohenwarter and Jones, 2007).

Statement of Problem

In the teaching and learning of geometry, it has been often realized that students still lack the cognitive and process abilities in the total understanding of circles. Although the teacher delivers the required knowledge to assist students in understanding the concepts of circles, students seem to face a challenge in applying this knowledge to a given task. It is as though something more is required to guide students so that they are able to manipulate circle properties to truly understand and visualize the properties of circles. This perception is supported by research (Battista, 1999; Prescott, Mitchel more and White, 2002) whereby students faced challenges in studying geometry and many struggle to grasp the concepts and required knowledge.

GeoGebra might play the role in filling up the gap by assisting students to visualize and understand circles through exploration. A review of literature also shows that using GeoGebra has an impact on students' understanding of geometry. Dogan (2010) revealed that GeoGebra had positively affected students' learning and achievement and better results using the software improved their motivation.

Another study by Erhan and Andreasen (2013) also suggested that students improved their mathematics understanding after using the dynamic geometry software. Students were able to explore and form conjectures and therefore had better scores as well. A study done in Malaysia to evaluate the impact of GeoGebra in learning transformations by Bakar, Ayuba, Luan and Tarzimi (2002) revealed that secondary school students achieved higher with the use of GeoGebra. However, several challenges impedes the use of GeoGebra in Secondary schools, preventing the students from benefiting from the

opportunities inherent in the use of GeoGebra for teaching and learning of Mathematics. It is in the light of this that this study examines the issues and challenges in the use of GeoGebra in teaching and learning of Mathematics in Secondary Schools in Makurdi Metropolis.

Objective of the Study

The main objective of the study is to examine the issues and challenges in the use of GeoGebra in teaching and learning of Mathematics in Secondary Schools in Makurdi Metropolis. The specific objectives are:

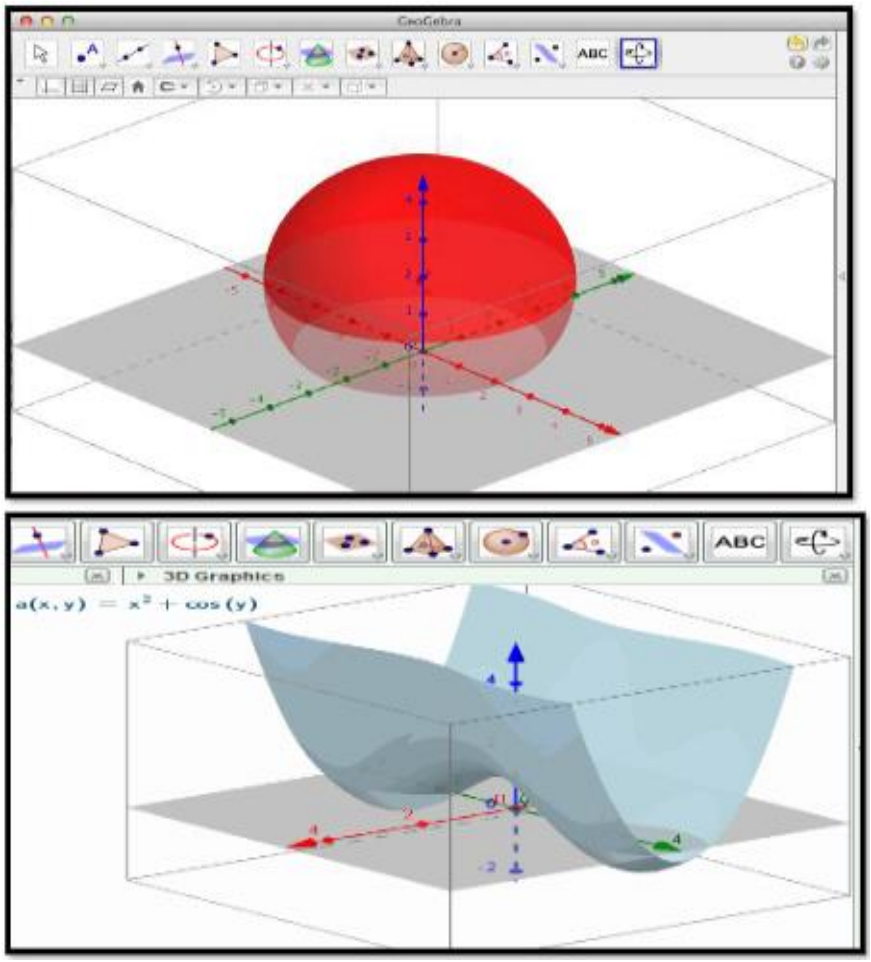
a) To establish mathematics teachers' competence in the use of GeoGebra for teaching of Mathematics.
b) To establish the challenges of using Geogebra in Teaching and learning of Mathematics in Secondary Schools in Makurdi Metropolis.
c) To proffer solutions to the challenges of using Geogebra in Teaching and learning of Mathematics in Secondary Schools in Makurdi Metropolis.

2.0 LITERATURE REVIEW

Conceptual Framework

GeoGebra Software

GeoGebra was designed by Markus Hohenwater as an open-source dynamic mathematics software that incorporates geometry, algebra and calculus into a single, open-source, user-friendly package (Hohenwarter, Jarvis, and Lavicza, 2008). This software combined features of older software programs such as Maple, Derive, Cabri and Geometer's Sketchpad (Sahaa, Ayuba, & Tarmizi, 2010). GeoGebra is a free and user-friendly software that connects geometry and algebra (White, 2012b).



GeoGebra's support materials are rather impressive (especially for a free program), where it provides wide-ranging online help feature, 42-page help manual in pdf format, downloadable tutorials, and a variety of detailed lessons using video-based step-by-step examples. These materials are very concise, easily accessible, and professionally done, with supplementary suggestions contributed by users. This concerted assisted environment is described as focusing on "quality versus quantity" in the GeoGebra website (Grandgenett, 2007).

Challenges in the Use of GeoGebra in Mathematics Teaching

The fast growth of modern technologies in mathematics teaching and learning has raised new challenges for teachers since it implies "using new kinds of mathematical tasks and modifying the nature of mathematical activities in classroom based on a set of pedagogical principles. For instance, while Dynamic Software such as Computer Algebra System (CAS),

Sketchpad, and GeoGebra, have been recognized as innovative tools with high potential to enhance students' learning of mathematical concepts, a few researchers believe that overuse or "unclear contractual relations about the role of CAS lead to students' metacognitive shifts, resulting in a lose of their focus on the original mathematical concept to something else (e.g. specific procedures). Jankvist and colleagues, who examined three empirical examples of the use of Computer Algebra System (CAS) in a secondary school mathematics class, reported that all examples "lead to didactical problems surrounding the situation and unclear expectations between teacher and students, involving loss of students' mathematical skills and confidence, loss of global mathematical perspective, and the students losing sight of the mathematical objects in question. The authors further argue that using some CAS packages in educational settings, while they were initially developed for professional use (e.g. Maple), or easement of students' mathematics work (e.g., Photomath or Cossincalc), might create unforeseen didactical consequences (Voogt, 2008).

In another study, the authors argued that although using Computer Algebra Systems in upper-level secondary schools has high potential for mathematics procedural concepts to be followed, it leads to black boxing of the central concepts that are the focus of the teaching. This means that although students might hang on to the procedural and pragmatic approaches, at the same time, there is a substantial risk that they do not acquire deep understanding of central concepts and topics. These critical viewpoints show that there is still need to analyze how technology affects and strengthens students' learning and conceptual understanding of mathematics. Specifically, it seems imperative that teachers need to understand how and through what cognitive process various instrumental tools can help students to enhance their learning of mathematical concepts (Bu and Schoen, 2011).

Mathematics can be regarded as a challenging subject. Learning Mathematics involves understanding the theories and formulas to describe something. In the typical classroom, the challenge for the students is to explore complex problems. With advances in multimedia technology, learning difficulties can be overcome. The challenge is more complex in teaching and learning of Mathematics, where teachers have to balance the mental, stationery and digital tools for teaching and learning that involve abstract mathematical concepts that is difficult to be understood by students (Prieto, Sordo Juanena and Star, 2013). Technology plays an important role in the development of the educational process (Gursul and Keser, 2009). Existing technology equipment such as GeoGebra, Geometer's Sketchpad and Mathematical should be used to the maximum by the educators. The use of technology is important because it serves as an object of education, which affect the learning content and objectives, and as a medium to improve the teaching and learning process (Voogt, 2008). Despite the remarkable benefits of using GeoGebra in enhancing students' learning of mathematics and providing great opportunity for visualization, manipulation, and exploration of geometrical figures and mathematical concepts, a considerable number of teachers are still struggling with the task of effectively using it for everyday teaching (Hohenwarter, Hohenwarter, and Lavicza, 2010; Preiner, 2008). According to Žilinskienė (2015), even though teachers have access to computers and appropriate software is available both in schools and at home, technology is rarely integrated substantially into everyday teaching.

Theoretical Framework

Information Processing Theory

Information Processing Theory simply explains how information is entered, analyzed, stored, and retrieved in humans' minds. Based on this theory, the human brain, like a computer, processes the received information rather than respond to the external stimuli. Information Processing Theory explains three main components, namely, sensory memory, working memory, and long-term memory. Sensory memory refers to all the gained experiences through five senses from the environment (Bu and Schoen, 2011). Working memory is defined as a temporary storage system under attentional control that underpins our capacity for complex thought. Willingham defines working memory as the place in the mind where thinking happens. The salient feature of working memory is its extremely limited capacity. Long-term memory holds information that is much longer lasting and it has a larger capacity than the working memory. In a metaphoric language, long term memory is the vast storehouse in which you maintain your factual knowledge of the world. Working memory is an assumed place in our brain where learning occurs by combining and processing the information gained from environment-driven and factual knowledge derived from long-term memory to construct new knowledge.

Diffusion of innovation Theory

This study used the Diffusion of Innovation Model (DIM) by Rogers (1995) as a lens for interpreting teachers GeoGebra uptake tendencies. DIM is a theory that seeks to explain how, why, and at what rate new ideas and technology spread through cultures. In this study the assumption is that teachers' perception and rate of GeoGebra uptake explains the status of use of GeoGebra in mathematics classrooms (Agyei and Voogt, 2011). DIM explains four main elements that influence the spread of a new idea. These elements include: innovation, communication channels, time, and social systems. The Diffusion of Innovation model is the main model that explains how adoption of technology takes place since it is mostly used by marketers for new innovations. Innovators of technology are normally the least in number, making up only 2.5% of a population while the early adaptors are few and make up 13.5% of a population. Early majority take up the software to use it only if they are sure that it will work and that it is useful to them. These require that the dots are joined and their questions are answered. This group requires encouragement to use an innovation. On the other hand, the late majority group wants to see the innovation working then they can use it (Hutkemri and Nordin, 2011). In every population, according to the diffusion model, there is a Each of the levels in the DIM model can be used to explain the feasibility of using GeoGebra in the selected secondary schools in Makurdi Metropolis, Benue State.

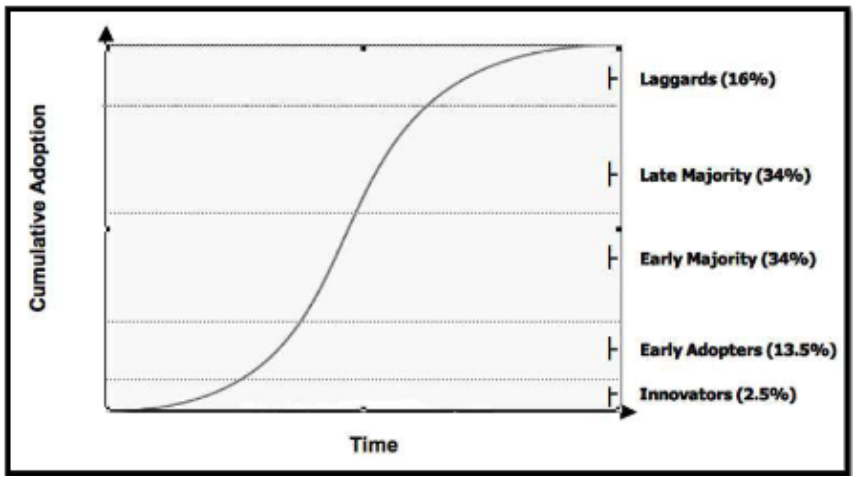


Figure 1: Diffusion of Innovation Graph

Empirical Framework

Hutkemri and Zakaria (2012) conducted a study on the effect of GeoGebra on student's conceptual and procedural knowledge of function. The purpose of the study was to identify the conceptual and procedural knowledge on the topic of function based on types of group and gender. This research involved 284 students from two uppersecondary schools in Rokan Hulu, Riau, Indonesia. Among these students, 138 were placed in the experimental group (use of GeoGebra software) while the remaining 146 students were in the control group. Data were collected using the conceptual and procedural test on the topic of function. Ttest, one-way analysis of variance (ANOVA), and two-way ANOVA, were employed using the Statistical Package for the Social Sciences (SPSS 19.0). The findings of the study showed that there were significant differences in the conceptual and procedural knowledge of students based on the type of group. However, there was no significant difference in students' conceptual and procedural knowledge based on gender. The findings of the study give implications to the use of GeoGebra in learning mathematics. The effectiveness of some technological tools which enables the linking of visualization to linear equation such as GeoGebra was examined in many studies.

Kabaca, Çontay and İymen (2011) purposed to construct the concept of parabola with the relationship between its algebraic and geometric representation by using GeoGebra. A learning environment supported by GeoGebra including 4 phases was prepared and the lesson was implemented in one class hour. GeoGebra was used as a presentation tool and students examined the algebraic and geometric representation of a parabola in the fourth phase. The 11th grade level class (SS2) including 23 students was videotaped during this hour. The students' important reactions were reported and interpreted. As a result, the 4 phases learning environment supported by GeoGebra was found practical and beneficial in terms of examining some advanced properties of a parabola.

Another research study involving the use of GeoGebra was conducted by Zulnaidi and Zakaria (2012). They examined the effects of GeoGebra on students' conceptual and procedural knowledge of function. 124 high school students participated in the study. The study used quasi-experimental nonequivalent pretest posttest control group design. The results revealed a significant difference between groups. It was concluded that GeoGebra improved high school students' not only conceptual knowledge but also procedural knowledge.

Doktoroglu (2013) investigated the effect of teaching Linear equation with Dynamic mathematic software. The purpose of the study was to investigate the effects of teaching linear equations with Dynamic Mathematics Software (GeoGebra) on seventh grade students' achievement compared to the regular instruction. Randomized post-tests-only control group design was utilized in the study. 60 seventh grade students (32 girls and 28 boys) of a public school in Yenimahalle district in Ankara participated in the study. The study was conducted in 2011-2012 fall semester, lasting 9 class hours in three weeks. The data was collected by three Mathematics Achievement Tests: Cartesian coordinate system achievement test (MAT1), linear relation achievement test (MAT2) and graph of linear equation achievement test (MAT3). The quantitative analysis was conducted by using analysis of covariance (ANCOVA). The results revealed that teaching Cartesian coordinate system and linear relation by using Dynamic Mathematics Software had no significant effect on seventh grade students' achievement compared to the regular instruction. On the other hand, the results also indicated that teaching graph of linear equations by using Dynamic Mathematics Software had a significant effect on seventh grade students' achievement positively. The foregoing background information constitute the theoretical rationale for testing the effectiveness of GeoGebra and demonstration method on students' academic performance in mathematic in Secondary School in Akwa Ibom North West Senatorial District.

This study used a survey research design. The population of the study is four secondary schools in Makurdi Metropolis purposively chosen from both private and public secondary schools. They are made up of junior secondary school students of Padopas Harmony Secondary School and Government College Secondary School Makurdi with a purposively picked population of one hundred and ninety (190) students and ten (10) Mathematics teachers chosen due to large sample size. The data for the study was collected using questionnaire, coded and analyzed using computer-based Statistical Package for Social Sciences (SPSS version 21.0 for Microsoft Windows). The validity and the reliability of the instrument

was established using the factor analysis. It was established that the instrument is valid and reliable as the validity score that considered Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity is above the threshold and the Cronbach Alpha Coefficient for reliability is 0.89 which is far above the recommended number of 0.7

3.0 RESEARCH METHODOLOGY

Table 1: Kaiser-Meyer-Olkin and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.957
Bartlett's Test of Sphericity	Approx. Chi-Square	3.594
	df	6
	Sig.	.031

Source: SPSS Result, 2019

A pilot test was conducted. The input variable factors used for this study were subjected to exploratory factor analysis to investigate whether the constructs as described in the literature fits the factors derived from the factor analysis. From Table 1, factor analysis indicates that the KMO (Kaiser-Meyer-Olkin) measure for the study's three independent variable items is analysis surpasses the threshold value of 0.50 as recommended by Hair, Anderson, Tatham, and Black (1995). Therefore, we are confident that our sample and data are adequate for this study.

Table 2: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.533	38.318	38.318	1.533	38.318	38.318	1.300	32.500	32.500
2	1.034	25.862	64.179	1.034	25.862	64.179	1.267	31.679	64.179
3	.778	19.454	83.633						
4	.655	16.367	100.000						

Source: SPSS Result, 2019

The Total Variance Explained table shows how the variance is divided among the 4 possible factors. Two factors have Eigenvalues (a measure of explained variance) greater than 1.0, which is a common criterion for a factor to be useful. When the Eigenvalue is less than 1.0 the factor explains less information than a single item would have explained. Table 6 shows that the Eigenvalues are 1.533 & 1.034 are all greater than 1. Component one gave a variance of 32.500, Component 2 gave the variance of 31.679. The cumulative of the rotated sum of squared loadings section indicates that two components i.e component 1 and 2 accounts for 64.179 % of the variance of the whole variables of the study. This shows that the variables have strong construct validity.

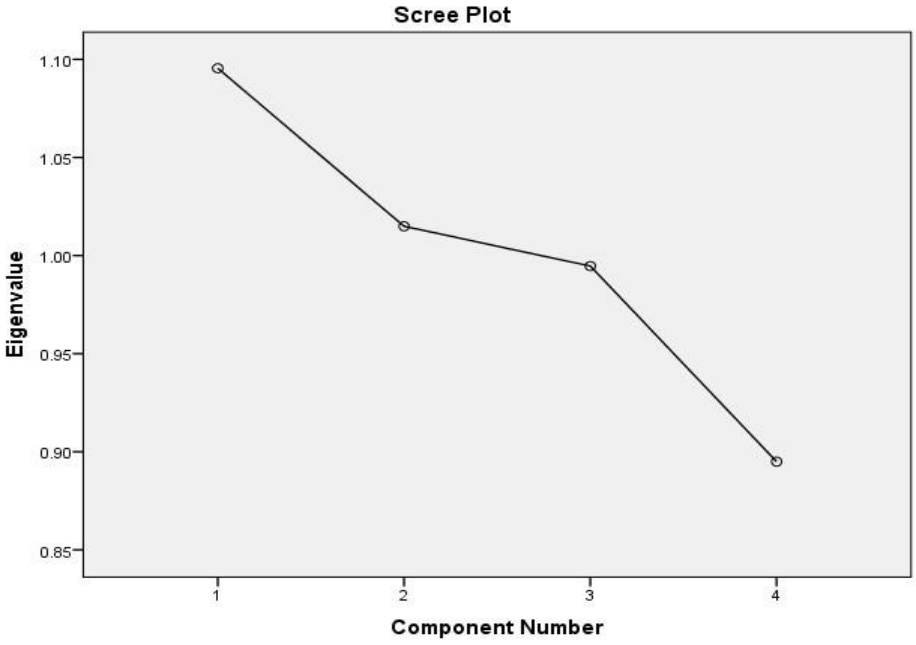


Figure 2: The Scree Plot

Source: SPSS Result, 2019

The Scree Plot shows the initial Eigenvalues. Note that both the scree plot and the Eigenvalues support the conclusion that these four variables can be reduced to two components. The scree plot also slopes downward after the second component.
The Scree plot shows that after the first two components, differences between the Eigenvalues decline sharply (the curve flattens), and they are less than 1.0. This again supports a two-component solution.

Table 3: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.871	.961	4

Source: SPSS Result, 2019

As shown by the individual Cronbach Alpha Coefficient the entire construct above falls within an acceptable range for a reliable research instrument of 0.70. The Cronbach Alpha for the individual variables is 0.871 and is found to be above the limit of acceptable degree of reliability for research instrument.

Table 4: Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QUS1	121.7500	427.461	.533	.448	.788
QUS2	118.1500	241.397	.411	.703	.658
QUS3	113.4500	263.418	.615	.741	.637
QUS4	106.5500	342.892	.650	.641	.780

Source: SPSS Result, 2019

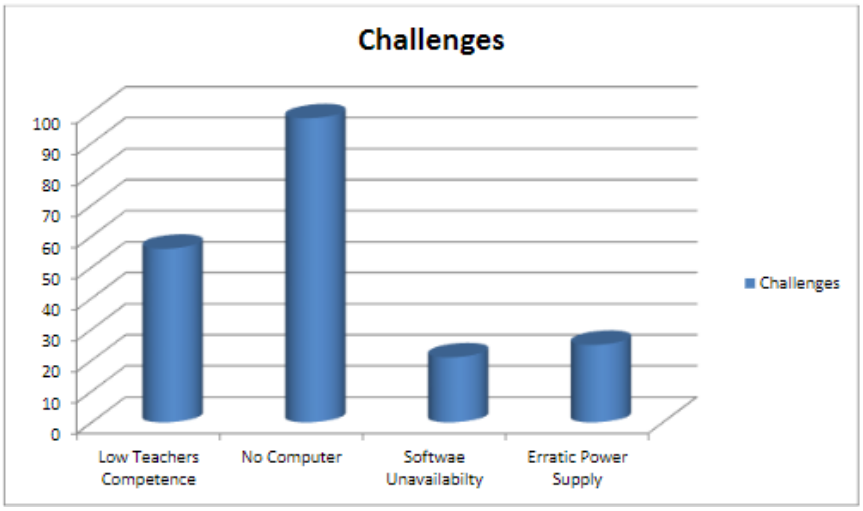
As shown in Table 4, an item-total correlation test is performed to check if any item in the set of tests is inconsistent with the averaged behaviour of the others, and thus can be discarded. A reliability analysis was carried out on the variables of the study values scale comprising two (2) items.
Cronbach's Alpha showed the questionnaire to reach acceptable reliability, $\alpha = 0.8271$. All items appeared to be worthy of retention, resulting in a decrease in the alpha if deleted. There is no exception to this in all the variables of the study as none of the items if deleted will improve the overall Cronbach alpha statistics. As such, none of the variables was removed. A correlation value less than 0.2 or 0.3 indicates that the corresponding item does not correlate very well with the scale overall and, thus, it may be dropped.

Method of Data Analysis
The Principal Component Analysis was used to extract the most relevant factor that are the challenges of using Geogebra in teaching and learning of Mathematics in the study area. Frequencies and percentages was also used to present descriptive data.

4.0 RESULTS AND DISCUSSION
This section presents the result of the study from the selected secondary schools in the study area in Benue State.

Table 5: Challenges using Geogebra for Teaching and Learning of Mathematics

S/No	Challenges	Frequency	Percentage
1	Low Teachers Competence	56	28.00
2	No Computer	98	49.00
3	Unavailability of the Software	21	10.50
4	Erratic Power supply	25	12.50
	Total	**200**	**100.00**



Source: Author's Computation, 2019

As shown by the result of the descriptive statistics on the challenges of using GeoGebra in teaching and learning, 28.0% of the respondents indicated that low teacher competence is one of the challenges preventing the use of GeoGebra in the teaching and learning of Mathematics in the selected Secondary Schools in the study area. Majority of the respondents, 49.0% indicated that unavailability or no computer is the major challenges preventing teaching and learning of Mathematics in the selected Secondary Schools in the study area. 10.5% of the respondents stated that unavailability of GeoGebra software is a challenge teaching and learning of Mathematics in the selected Secondary Schools in the study area. Also, 12.5% of the respondents indicated that erratic power supply is a key challenge in the teaching and learning of Mathematics in the selected Secondary Schools in the study area.

5.0 CONCLUSION AND RECOMMENDATIONS

Conclusion and Recommendation

In preparing students for being successful mathematical problem solvers, both for school mathematics as well as beyond school, rich problem solving experiences starting from the elementary school and continuing to secondary school needs to be implemented and appropriate technological tools like GeoGebra needs to be effectively used in solving these real-world based problems. Results from research empirical studies provide students, teachers and curriculum designers with details of evidence on how computer-based modeling activities can assist students in accessing higher order mathematical understandings and processes, for improved performance.

With the availability of dynamic mathematics software, like *GeoGebra*, teachers are able to make graphical representations of mathematics concepts. As the concepts are introduced with pictorial representations, teachers and their students are able to make the connections between the pictures, the mathematics concepts, and the symbolic representation. When presented with a new concept, students need to think, visualize and explore relationships and patterns. Technology makes all of this possible for them in a short amount of time.

Based on the review and findings of this study, it is recommended that:

1. Policy makers and school authorities should consider the acquisition of computer and GeoGebra software so that they can improve on the level of comprehension of mathematics being taught in school.
2. Teachers should strive to acquire training in the use of GeoGebra so that they can better help to improve the understanding of their students' knowledge in Plane Geometry I such as exterior angle theorem, properties of special triangles (isosceles and equilateral), and properties of the quadrilaterals before introducing Plane Geometry II thus circle theorems. This is because most of the difficulties students faced in learning Circle Theorems were related to geometric and algebraic relations.
3. Seminars/workshops should be organized for junior and senior school Mathematics teachers on the use of appropriate technological tools such as GeoGebra in the teaching and learning of mathematical concepts by experts in from the universities. This is because the application of GeoGebra in teaching and learning requires skills on the part of teacher.

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