THE EFFECT OF GEOGEBRA SOFTWARE ON ATTITUDE AND ACHIEVEMENT IN CIRCLE GEOMETRY AMONG FIRST YEAR STUDENTS OF KANO UNIVERSITY OF SCIENCE AND TECHNOLOGY WUDIL, KANO STATE

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Abstract

This study investigated the effect of GeoGebra software on attitude and achievement in circle geometry among first year students of Kano University of Science and Technology Wudil, Kano state – Nigeria. Three research items were raised in objectives, research questions and hypotheses respectively. A random sampling method was used in selecting 80 students to form two intact classes from a population of 152 students. The experimental group was taught using the GeoGebra software while the control group was taught using the conventional teaching method. The instrument used for the study was the Geometry Achievement Test 1 and 2 (GAT1 & GAT2) which were administered at the beginning and at the end of the study. The study also utilized the GeoGebra Attitude Questionnaire (GAQ) to investigate the attitude of the experimental group at the end of the study. The results of the study revealed that students taught with GeoGebra software (experimental group) performed better than students taught with traditional teaching method. It was also discovered that within the experimental group, the attitude of the students was found to be enhanced significantly. At the end of the study, recommendations were made on how to improve the effectiveness of teaching using the software. The reliability of the testing instruments were measured and found to be 0.73 and 0.68 respectively. The t-test was used to analyze the data obtained from the study.

Keywords: *GeoGebra Software, Circle Geometry, Mathematics Teaching, Random Sampling.*

Introduction

According to partnership for 21st century skills 2009, schools today are faced with ever-increasing demands in their attempt to ensure that students are well equipped to enter the workforce and navigate a complex world. Research indicates that computer technology can help support learning, and that it is especially useful in developing the higher order skills of critical thinking, analysis, and scientific inquiry (BECTA 2004).

Mathematics, to most, is a complex and difficult subject. The tendency for most students is to consider the subject as one that is boring, thus, creating lack of interest in the topics being discussed. This poses a great challenge for teachers and educators, especially in the primary and intermediate levels, wherein a good study habit and a firm grasp of basic concepts should be developed.

(Mistretta 2005) asserted that today's technology standards challenge teacher education programs across the globe to produce computer literate teachers who are confident in their ability to choose and incorporate instructional technology into their classroom teaching (ISTE, 2000). For this reason, it is crucial for teacher educators to share effective ways to prepare students to be able to incorporate technology into their future classrooms.

Mathematics is defined by some scholars as the study of quantity, structure, space and change. As abstract as that may seem, mathematics is at its core, a quest for absolutes, definitive solutions and answers to problems (Stokdyk 2016). Studying mathematics will not only provide more scientists and engineers, but also produce more individuals who can learn and think creatively and critically, since the workforce of today and tomorrow is fast trending towards the application of technology and which of course largely depends on mathematics.

It is essential that teachers and students have regular access to technologies that support and advance mathematical problem solving, and communication (NCTM, 2011)**.** When teachers use technology strategically, they can provide greater access to mathematics for all students. In an ideal mathematics classroom, the strategic use of technology will strengthen mathematics teaching and learning (Dick & Hollebrands, 2011).

Today, in many locations around the world, there is a significant gap between the knowledge and skills students acquire in school and the knowledge and skills employers need in workplaces. Most schools today are faced with increasing demands and difficulties in their quest to ensuring that students are well equipped for today's workforce around the world. Research reveals that technology can help to support learning, and that it is essentially useful as it enables students to acquire skills of critical thinking, analysis, and scientific inquiry.

Technologies such as Mathematics software, spreadsheets, scientific calculators, and statistical packages have become commonplace in many classrooms. This is in sharp contrast to the traditional mathematics classroom, which was dominated by pen and paper. (BECTA 2003) asserts that technology has changed the nature of teaching and learning in mathematics.

These changes caused by the use of technology have had some profound impacts on how teachers teach the subject of mathematics and how students engage in learning. Over the last two decades, educational authorities in Nigeria have worked hard to promote the use of ICT resources in the classroom setting. This move has been motivated by the need to improve the efficiency of teaching and learning as well as the need to ensure that students are properly prepared for their interaction with the real world.

(Safdar *et al*, 2011) rightfully observe that the major goal of the teaching-learning process is to provide students with skills that will help them earn livelihoods in future and become useful society members. It is therefore pertinent that education serves to conform to the development and innovations of our present time. The use of technology therefore, serves as a motivation for teachers and students because of its positive outcomes and achievement. Technology leads to teaching that is performance and achievement based due to its effectiveness.

Research indicates that while some teachers might express their reservations to using technology for teaching mathematics at first, these reservations do not last (Mkomange et al. 2012). As the students demonstrate good outcomes, a change occurs in teacher's believes and attitudes. This leads to changes in teacher practice to incorporate technology in teaching the subject.

Technology fosters the development of a culture of effective teaching by teachers. When using technology, teachers are encouraged to broaden curriculum objectives, make use of more problem solving examples and utilize an inquiry-based approach to learning (Jurdak, 2004).

Technology has been used to help cope with some of the “hard to teach” aspects of secondary mathematics. Students are wary of some mathematical topics such as geometry and trigonometry. In the traditional classrooms, teachers were often unable to make use of appropriate tools to simply the topic and foster student understanding.

Technology enables teachers to make use of learning aids that are designed to exploit the student’s visualization and modeling power to solve problems. Software applications such as Computer-Aided Design assist teachers to come up with simplified and interesting ways of teaching these hard topics in mathematics. Teaching mathematics with technology gives the teacher more tools with which to offer instructions to the students. A critical role of the teacher is to explain different concepts to the students and ensure that they understand the material being presented.

Unlike in the traditional setting where the teacher was confined to relying on drawings and handmade models, technology offers a wider variety of teaching aids. (Jurdak 2004) states that technology enables teachers to make use of simulations to better elaborate certain mathematical concepts. The ability of the teacher to explain mathematical concepts is facilitated by technology. (BECTA 2004) confirms that technology contributes to the effectiveness of teaching by offering ways through which the teacher can model abstract ideas and concepts.

The use of technology in teaching mathematics requires major changes to enable students conform to present reality in our modern society and workforce. Teaching mathematics with technology necessitates a significant change in the operation of teachers who have been teaching the subject using traditional methods, and who were themselves taught in traditional mathematics classrooms.

A key characteristic of technology is that it saves the student from having to engage in the time involving manual labour of computations (Jeng *et al*, 2010). In tasks such as drawing graphs, the student only needs to enter the correct data and the computer program will generate the graph. The student is therefore left with more time to engage in more important parts of learning mathematics such as analysing the computations made in a particular problem.

GeoGebra supports the realization of the above concerns. This software connects features of Computer Algebra System (CAS), Interactive Geometric Software (IGS) and spreadsheet. GeoGebra provides this functionality within an intuitive, user-friendly interface. It is an appropriate software for overcoming several difficulties, false beliefs and negative attitudes in mathematics classrooms. The overall teaching approach brings about new contextualized organization for mathematical contents which enable students to pass through the phases of discovering geometrical concepts and theorems as well as attaining the level of proving.

The GeoGebra Software

GeoGebra is a Dynamic Mathematics Software (DMS) for teaching and learning mathematics from middle school through college level (Hohenwarter & Preiner 2007). It is as easy to use as Dynamic Geometry Software (DGS) but also provides basic features of Computer Algebra Systems (CAS) to bridge some gaps between geometry, algebra and calculus. GeoGebra is open source software under the GNU General Public License and freely available at www.geogebra.org.

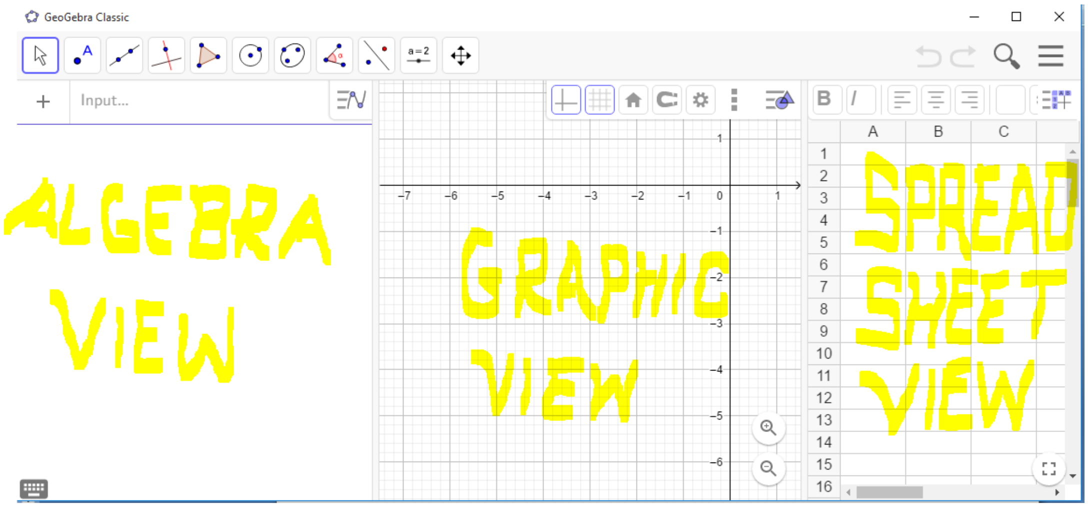
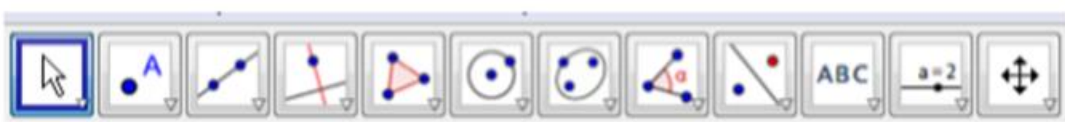


Fig. 1: GeoGebra User Interface

Note: When you click on the Graphics View the following toolbar appears:



and when you click on the Spreadsheet View the following toolbar appears:

Figure 1 represents the GeoGebra user interface. On each of the icons on the tool bar, if you click the small angle at the lower edge, the drop down menu will appear which will give you several other options of the icons. These icons are used for carrying out construction work on the graphic view. All representations of the same object are linked dynamically and adapt automatically to changes made to any of the representations, no matter how they were initially created. GeoGebra is currently used in 190 countries and has been translated into 52 languages (Hohenwarter & Preiner 2007). The mission of GeoGebra is to help mathematics learning for students world-wide. This free and multi-platform dynamic software allows students to interactively discover mathematical concepts and relationship among them. It helps millions of children to understand algebra, geometry, calculus, statistics and many other fields of science in a deeper way.

Review of Related Literature

(Herceg and Herceg 2010) conducted a study on two groups of students. One group used applets only, while other group used the GeoGebra software and applets. The Study tested how to incorporate computer – based leaning to reduce the working process of numerical integration. The result of this study showed that the GeoGebra experimental group gained more knowledge and skills than the control group.

(Bakar *et al*, 2009) compared GeoGebra to a software program created by them on two groups of Malaysian secondary school students and found that students using the GeoGebra software to study the transformation topics achieved better results than using the created software.

The findings of (Zakaria and Lee, 2012) revealed that mathematics teachers in secondary schools have a positive attitude toward the use of GeoGebra. They concluded that mathematics is a subject that is abstract and that requires the collective imagination of students and teachers, particularly in the areas of geometry and transformations. The use of technology exposes students to learning without boundaries and also promotes student centered learning, where the teacher acts as an enabler or facilitator even when using premade GeoGebra files. GeoGebra software is expected to help mathematics teachers diversify their teaching methods to facilitate students' understanding of mathematics concepts through effective teaching and learning.

Also, based on the students' results in test results, questionnaire answers, and interviews, (Takači, Stankov, and Milanovic 2015) determined that GeoGebra allowed for easier learning of the mathematics students. GeoGebra software allowed students using pre-made GeoGebra activities to verify each step in the process of solving a math problem.

In their study, (Zengin, Furkan, & Kutluca 2012) found that dynamic mathematics software like GeoGebra on students' success in teaching of trigonometry had some major impacts on learning. Their sample size consisted of 51 students. Their experimental group were taught lessons with GeoGebra software in a computer-assisted teaching methodology and the control group was exposed to the lessons taught with a mostly constructivist format. The researchers collected data for a five-week period of application which showed a meaningful difference between experimental and control groups' achievement in trigonometric learning. The researchers concluded that the difference was in favor of the experimental group which had pre-made materials using GeoGebra.

In their research, Thambi and Eu (2013) investigated student achievement with fractions using the software GeoGebra. Their quasi-experimental research design compared the achievement of two groups of fourth-grade students. The results showed significant difference between the mean scores of the control and experiment groups of students and illustrated that students in the experiment group performed exceptionally when using GeoGebra over the control group with more common learning method of teaching fractions without such software. The implications from this study were helpful in proposing other innovative way of teaching and learning fraction concepts as well as helping students in visualizing fraction concepts while using this software.

Also in a study conducted by (Shadaan and Leong 2013) to investigate students' understanding in learning circles using GeoGebra. Fifty-three year 9 (form 3) students from two intact classes participated in the study with one class assigned as the experimental group and the other as the control group. Findings from this study showed a significant difference existed in the mean scores between those two groups. The result indicated that students in the experimental group outperformed those in the control group. In addition a survey instrument was used to elicit students' perception on the use of GeoGebra. Students in the experimental group showed positive attitude and perception. Analysis of the questionnaire responses indicated a positive overall perception of using GeoGebra in learning about circles.

Statement of the Problem

Academic achievements in mathematics amongst students of first year students in the university have not been encouraging over the years. This could be attributed to the recurring challenges of poor method of teaching as well as lack of sufficient knowledge of the subject matter. Generally, students at the secondary school level consider mathematics as a very difficult subject and not easily surmountable, as such students develop inbuilt fear of mathematics. There is no doubt that some mathematics teachers have contributed significantly to the low interest of students in mathematics. They impart the knowledge of mathematics with paper and pencil in collaboration with textbook and the chalkboard. These have been the routine over the years. As a result of all these recurring factors, students develop poor attitude towards learning mathematics. For these and other numerous reasons therefore, the authors strongly support the use of classroom technology towards teaching and learning of mathematics. Therefore, this study investigated the effect of GeoGebra Software on attitude and achievement in circle geometry among first year students of Kano University of Science and Technology Wudil, Kano state.

Objectives of the Study

The main objective of this study was to investigate the effect of GeoGebra Software on attitude and achievement in circle geometry among first year students of Kano University of Science and Technology Wudil, Kano state.

In view of this, the specific objectives of the study therefore, are to:

1. find out if there was any significant difference in the geometry achievement of the experimental and control group before intervention (i.e. before using the GeoGebra Software).
2. determine whether there was any significant difference in the geometry achievement of the experimental and control group after intervention (i.e. after applying the GeoGebra software)
3. find out the extent to which the Geogebra software will positively change the attitude of students within the experimental group.

Research Questions

Specifically, the study sought to answer the following research questions:

1. To what extent does the geometry achievement of the experimental group differ from the control group before intervention?
2. How does the geometry achievement of the experimental group differ with that of the control group after intervention?
3. In what way has the Geogebra software impacted on the attitude of students within the experimental group?

Research Hypotheses

Based on the research questions stated above, the following hypotheses stated in null form were tested at $p \leq 0.05$ to determine the relationship between the variables in the study.

1. **$H0_1$**: There is no significant difference in the mean geometry achievement of the experimental and control group before intervention
2. **$H0_2$**: There is no significant difference in the mean geometry achievement of the experimental and control group after intervention.
3. **$H0_3$**: There is no significant change in attitude of the students within the experimental group after exposing them to teaching with Geogebra software.

Significance of the Study

The study was majorly carried out so as to improve the geometry achievement level of students in the Department of Computing and Mathematics Education, Kano University of Science and Technology Wudil. The study also aimed at changing the attitude of the students positively so as to see mathematics entirely from a new perspective. Earlier studies revealed that GeoGebra Software is capable of changing the perception of students as well as increasing their speed and accuracy.

Methodology

Research Design: A pretest –post-test quasi-experimental design was used in the study. The design had the experimental group (EG) and a control group (CG).The EG was exposed to the treatment using the Geogebra software while the CG was treated without the Geogebra software.

Population

The population of the study consisted of all 152 first year undergrduate students of Computing and Mathematics Education Department of Kano University of Science and Technology Wudil, Kano State, Nigeria.

Sample

A total number of 80 students were randomly selected out of a population of 152 undergraduate students in the department of Computing and Mathematics Education, Kano University of Science and Technology, Wudil, Kano State.

Sampling Technique

Out of a population of one hundred and fifty two (152), eighty students (80) students were randomly selected at the beginning of the study to form two intact classes for the experimental and control groups.

Research Instruments

This study used three instruments for collection of data, namely:

(i) Geometry Achievement Test 1 (GAT.1)
(ii) Geometry Achievement Test II (GAT.II)
(iii) GeoGebra Attitude Questionnaire (GAQ)

The Geometry Achievement Tests 1 & II were administered to both experimental and control groups at different levels of the research. The Geometry Achievement Test 1 (GAT.1) was used at the pretest level i.e as a readiness test in order to examine the entry level of the experimental and control group students at the beginning of the study, while the Geometry Achievement Tests II was used at the posttest level i.e at the end of the treatment so as to compare their performance with the pretest. The topics included in the instruments were:

1. Triangles and Polygons

2. Circle Geometry.
3. Arcs and Chords

Instrumentation

As a necessary requirement, permission was sought from the Dean Faculty of Science and Technology Education and also from the Head of Department Computing and Mathematics Education. One mathematics teacher served as research assistant. He was trained for one working week (5 days) by the researcher, and was also given detailed plan and instruction on the study prior to the treatment.

A pretest was administered to the students in the experimental and control groups before embarking on the treatment. The pretest was administered in order to ensure that they have equal ability before embarking on the treatment.

The second phase was the treatment exercise which lasted for two working weeks (10 days). The experimental group was taught using the GeoGebra software in the laboratory containing 40 desktops, one student assigned to a desktop. The treatment lasted for 40 minutes. Also, the questionnaires were administered to the experimental group only at the end of the treatment.

The control group was taught using the conventional teaching method and also lasted for the same duration of time as the experimental group. At the end of the treatment, a post test was administered to both groups and results analyzed using the t – test statistical tool.

Table 1: Phases of Instrumentation

Phases	Parameters	EG	CG
1	Pre-Achievement Test	+	+
2	Lesson with GeoGebra Software	+	–
3	Lesson without GeoGebra software	–	+
4	Post Achievement Test	+	+
5	Questionnaire	+	–

Table 1 above represents the steps adopted in the data collection procedure where positive (+) indicates utilization of instrument while negative (–) indicates no instrument was utilized. EG stands for Experimental Group while CG- Control Group.

Validity and Reliability: The values obtained for GAT.1 and GAT.2 are 0.723 and 0.689 respectively. These values are in the range of kunder Richardson reliability coefficient of 0.92. Also, the study used a modified questionnaire based on Shadaan and Leong (2013) study. This questionnaire contains statements which reflect the students' perception on the use of GeoGebra software. The reliability coefficient of the questionnaire is α=0.89 which indicates good internal consistency.

Manual for the Experimental Group Using the GeoGebra Software

The researcher projected the GeoGebra window on the screen using a projector which enabled him to explain and demonstrate the construction process using the GeoGebra tools, commands and features while the students pay attention and take notes. After repeated constructions, demonstration and solution to some exercises, the participants were allowed to carry out the exercises with little guidance by the researcher and the regular mathematics teacher. Figure 2, 3, and 4 are typical examples of the presentations made by the researcher during the lessons.

The researcher again demonstrated step- by - step the construction work and some exercise while the participants were encouraged to work along with him. Thus, every participant will keep up with the pace of the researcher, although questions were posed in between.

Finally, the researcher introduced a new task and encouraged the participants to find their own solution using the Geogebra software.

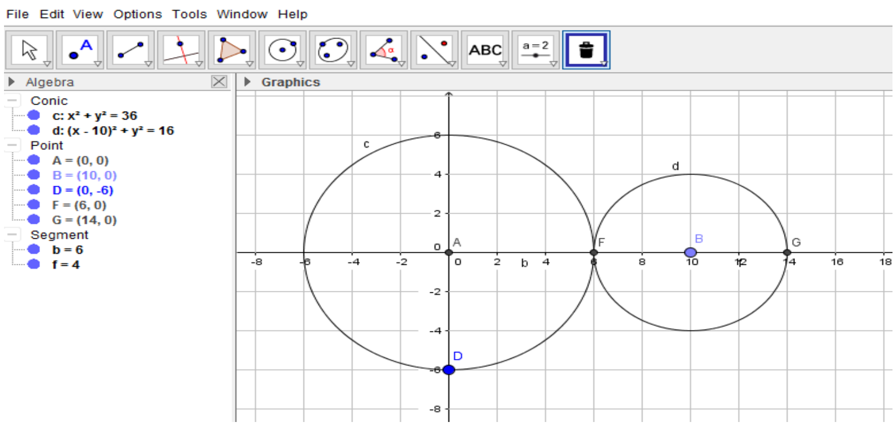


Fig. 2: Representation of circles with Different Radii

Figure 2 above, gives the formation of circles with different radii. It was aimed at presenting to the students the equation of a circle, how it was obtained and how to carry out further calculations on circle geometry.

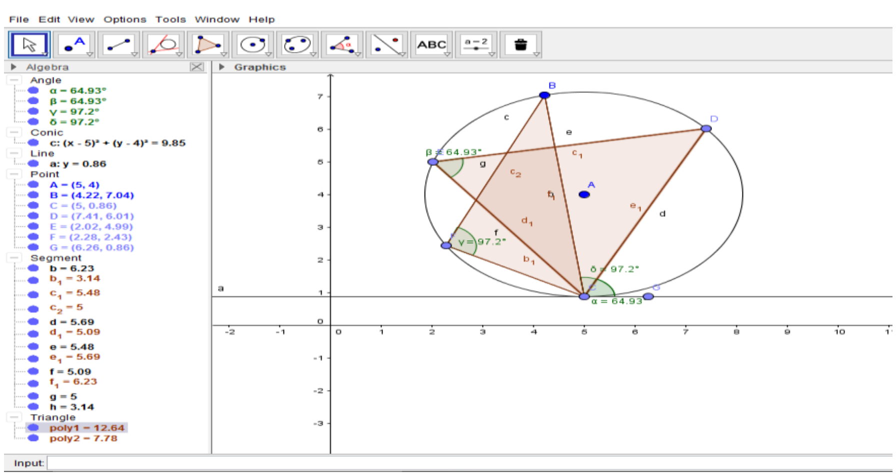


Fig. 3: Representation of Cyclic Triangles and Tangent

Fig. 3 above was aimed at demonstrating the theorem "The Angle between a Tangent and a Chord through the point of contact is equal to the angle in the alternate segment.

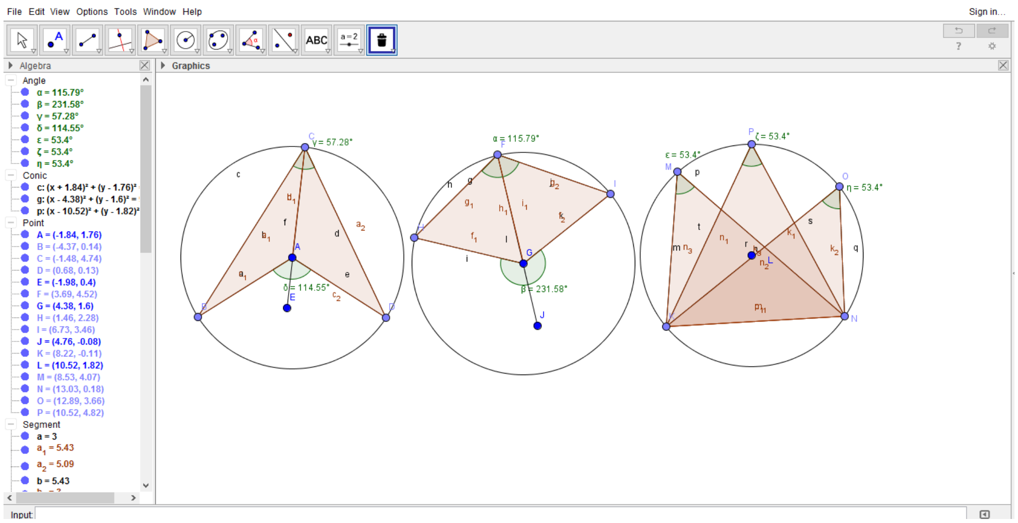


Fig 4: Formation of Cyclic Triangles and Quadrilateral

In Fig. 4, there are three diagrams. The first two was presented in order to demonstrate the theorem which proves that "Angle at the center of the circle is twice the angle formed at any point on the circumference". While the third diagram was to demonstrate the theorem "Angles in the same segments are equal."

Hypotheses Testing

H0$_1$: there is no significant difference in the mean achievement scores between the experimental group and the control group before the treatment.

Table 2: Pretest Achievement for EG and CG

Group	N	Mean	SD	df	t-cal	t-crit	Dec.
Experimental	40	62.60	2.18	78	0.209	1.980	Retained
Control	40	62.35	2.40				

From Table 2, it is observed that t-critical has a value of 1.980 while the t-calculated has a value of 0.209 indicating that the t-crit. is greater than the t-cal. Thus, the decision is retained. This implies that both groups have same ability level at the beginning of the study.

H0$_2$: there is no significant difference in the mean achievement scores between the experimental group and the control group after the intervention.

Table 3: Post-test Achievement for EG and CG

Group	N	Mean	SD	df	t-cal	t-crit	Dec.
Experimental	40	81.97	5.85	78	2.475	1.980	Rejected
Control	40	68.95	3.58				

From Table 3, The t-calculated obtained is 2.475 while the t-critical is 1.980 indicating that the t-cal is greater than the t-crit at 0.05 level of significance. Hence, the decision is rejected. This implies that, the experimental group has higher level of geometry achievement than the control group.

$H0_3$: There is no significant change in attitude of the students within the experimental group after exposing them to teaching with Geogebra software.

Table 4: Summary of Students Attitude Response Questionnaire

S/N		YES	NO
1	I was excited about using GeoGebra software	92.5%(37)	7.5%(3)
2	I learnt a lot using GeoGebra	95%(38)	5%(2)
3	I felt confident using the GeoGebra software during the activities	90%(36)	10%(4)
4	I was very engaged in the learning process	87.5%(35)	12.5%(5)
5	I benefited a lot through the teacher-students interaction	92.5%(37)	7.5%(3)
6	I was able to visualize and answer the questions after each activity	85%(34)	15%(6)
7	I was able to think creatively and critically in the discussions and during the question and answer session	95%(38)	5%(2)
8	I was able to make logical assumptions when attempting to hypothesize	82.5%(33)	17.5%(7)
9	I enjoyed learning mathematics much more using GeoGebra	95%(38)	5%(2)
10	I was able to form better connections between previous learning and new learning	87.5%(35)	12.5%(5)

Results from Table 4 show that students generally responded positively towards the use of GeoGebra software. Majority of the students indicated their willingness to accept and use the software. 92.5% of them mentioned that they were quite excited using Geogebra software, while 95% of the students mentioned that they learnt a lot using GeoGebra software. 90% indicated confidence in using the software while 87.5% of the students felt that the software highly increased their level of engagement in the learning process. 85% were able to visualize concepts and answer the questions after each activity. About 82.5% of students said that they were able to make logical assumptions when attempting to hypothesize. 95% mentioned that they enjoyed learning mathematics much more when using GeoGebra, while 87.5% were able to form better connections between previous learning and new learning. However, only 7% reported that were not so confident when using the GeoGebra software. Based on the percentage of the students that indicated strong support for the use of the software, it was concluded that there is a significant positive change in attitude of the students within the experimental group.

Discussion

The study investigated the effectiveness of GeoGebra Software on attitude and achievement in mathematics among first year students of Kano University of Science and Technology Wudil, Kano state. Findings from the study showed that the experimental group (students taught with GeoGebra software) indicated a high level of achievement when compared to students in the control group (students taught without the software). The students in the experimental group obtained **62.60** and **2.18** in the mean score and standard deviation respectively of the pre-achievement evaluation while at the post-achievement evaluation, they obtained **81.97** and **5.85** in the mean and standard deviation respectively indicating a high level of achievement. The students in the control group obtained **62.35** and **2.40** in the mean and standard deviation of the prê-achievement evaluation while in the post-achievement evaluation the students obtained **68.95** and **3.58** in the mean and standard deviation respectively. Therefore, comparing the mean scores in the post-achievement evaluation of both groups, it was observed that the experimental group achieved higher scores than the control group.

This finding was in line with the findings of (Thambi and Eu 2013). In their research, they investigated students' achievement with fractions using the software GeoGebra. Their quasi-experimental research design compared the achievement of two groups of fourth-grade students. The results showed significant difference between the mean scores of the control and experiment groups of students and illustrated that students in the experiment group performed exceptionally when using GeoGebra over the control group with more common learning method of teaching fractions without such software.

Dynamic geometry programs are not only used to make learning environment objective but also create a constructivist-teaching environment for learning mathematics. Technologies like GeoGebra can help students achieve a higher level of cognition. Ipek, Orhan, Akbasoglu, and Kaplan (2015) found in their research that software gives opportunities for students to create geometric shapes in a virtual environment, to find relationships between shapes, to scaffold theorem to proof this relationship and to change this scaffold according to the request or understanding. Math software like GeoGebra on this structure also allows for better understanding of measurement and comparisons. Teachers can explore to use software like GeoGebra and the activities found to better help their students learn. At the same time, teachers will be encouraged to use technology and to create new activities. Ipek, et al. feel that students will be able to explore and develop analytical and intuitive properties of mathematics. Teachers provide students to learn by trying, doing and exploring by integrating technologies like GeoGebra into their instruction. Other research has supported the use of GeoGebra as an effective means of effectively teaching mathematics. One thing to mention in advocating this software as well is the fact that it is completely free and constantly being updated to enhance effectiveness for users.

Conclusion

This study was able to positively project the effectiveness of using GeoGebra software in teaching and learning mathematics in our University. Findings from the study revealed how the software was used to improve the achievement of students in mathematics. The use of the software in teaching some mathematics concepts such as equations of circles, theorems on cyclic quadrilaterals and triangles has revealed its impact on the achievement of undergraduate students in the university. The software can therefore be used to other topics in mathematics teaching.

The study concludes that the GeoGebra software proves to be an effective software that will enhance mathematics achievement among mathematics students in the University.

In conclusion, the findings from this study is in line with the research from Zengin, Furkan, & Kutluca (2012) which found that using GeoGebra to teach math has been proven to increase achievement scores in mathematics. The study findings show a significant difference between the average scores of the students' on the posttest favoring the GeoGebra group when learning math concepts.

Recommendations

(i) Research Studies should focus on specific areas of mathematics rather than looking at mathematics from a general perspective.

(ii) Government and other stake holders should encourage the use of computers for teaching and learning mathematics so as to make mathematics more exciting and interesting for the students.

(iii) As a matter of policy, teachers should be encouraged to develop more skills in computer as well as to learn how to use the software in the teaching and learning of mathematics in our universities.

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