UNIVERSITY OF EDUCATION, WINNEBA

INVESTIGATING THE EFFECT OF GEOGEBRA LEARNING TOOL ON THE ACQUISITION OF CONCEPTS IN CIRCLE THEOREMS BY SENIOR HIGH SCHOOL STUDENTS IN ANLOGA DISTRICT

KAFUI KUGBLENU

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Graduate Studies, in partial fulfillment
of the requirements for the award of the degree of
Master of Philosophy
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DECLARATION

Student's Declaration

I, Kafui Kugblenu, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and acknowledged is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: …………………………………

Date: ……………..………..……………….

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on the supervision of thesis laid down by the University of Education, Winneba.

Professor C. A. Okpoti

Signature: …………………………………

Date: ……………..………..……………….

DEDICATION

I dedicate this thesis to my family, friends and all my students.

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ABSTRACT

The main aim of the study was to investigate the effect of GeoGebra learning tool on the acquisition of concepts in circle theorems by Senior High School Students in Anloga district in Volta region. The study used mixed method research design. Quantitative and qualitative data were collected to answer the various research questions. The sample of about 101 SHS 3 students comprising 50 in the control group and 51 in the experimental group and 10 mathematics teachers from the two schools were randomly and conveniently selected respectively for the study. The study lasted for three weeks. Circle Theorems Achievement Tests (CTAT) was administered to both intact classes (control and experimental) as pre-test and after the intervention a similar CTAT was administered as post-test. During treatment, the experimental group was taught using GeoGebra learning tool while the traditional instruction was applied to the control group. Three research questions and one hypothesis guided the study. However, interview data showed students negative attitudes and teachers' teaching methods (use of traditional teaching method) were the main cause of students' poor performance in circle theorems. Also, independent samples t-test results revealed that the traditional method did not have significant impact on the academic performance of students in circle theorem. It was revealed that Geogebra learning tool has significantly improved achievement of students in circle theorem. The result of the independent-t test comparing the post-test results of the two groups showed that there was a significant difference between mean performance scores of the control group (M = 22.26, SD = 4.575) compared to Experimental group (M = 44.76, SD = 5.054); t(99) = 3.985, hence, the null hypothesis that there is no statistically significant difference in the mean post scores between students utilizing GeoGebra learning tool and traditional method was rejected as $p = 0.000 < 0.05$.The finding showed that there is a statistically significant positive effect for students who used GeoGebra learning tool to learn circle theorems. Students taught with GeoGebra teaching tool performed better than their counterparts who used traditional teaching method to learn circle theorems. Also, the GeoGebra teaching tool made the lessons more interesting, practical and easy to acquire concepts. It was concluded that the Geogebra teaching tool increased students' conceptual understanding in circle theorems and hence increased students' achievement in circle theorems than the traditional instruction. Thus, Geogebra teaching tool as a supplement to traditional teaching method is more effective than traditional instruction alone. It was recommended that teachers should incorporate GeoGebra teaching aid in the teaching of circle theorems.

CHAPTER 1

INTRODUCTION

1.0 Overview

This chapter discusses the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, research hypothesis, significance of the study, delimitations of the study, limitation of the study, definition of terms and Organization of the study

1.1 Background

In the information era we live in, it is inevitable that technology affects how we teach and how we learn. As a result of research studies for new approaches to the process of teaching-learning, which have been conducted for many decades, new supportive techniques that enable effective teaching and learning have been developed. One of these techniques is based on the integration of technology into the educational field, especially the use of ICT in classrooms. Many research studies showed that ICT (Information and Communication Technology) is useful as a supportive tool in the teaching and learning environment. In the mathematics classroom, the use of ICT can help students and teachers perform better in calculations, analyses of data, exploration of mathematical ideas and concepts and the association of these ideas and concepts with real life examples, thus resulting in permanent and effective learning in mathematics and higher mathematics achievement (Rohani Ahmad Tarmizi, Ahmad Fauzi Mohd Ayub, Kamariah Abu Bakar 2010).

Nowadays, technology is influencing students' learning style preference from the very beginning of their schooling. Pupils prefer to see, to touch, and to comprehend what they learn. Scholars have also deduced that technological literacy is an essential skill of teaching with the power to motivate and create opportunities for students to comprehend, construct and explore new approaches to problem-solving (Bray & Tangney 2017; Lawless & Pellegrino 2007; Mainali & Key 2012). Thus, seamless integration of technology with learning has the advantage of enriching the processing power of students' mind to a new domain of knowledge representation through modeling, simulation, and visualization (Ahmad et al., 2010; Akcay 2017; Kaput et al., 2008). Hence technologies are used as a medium to address conceptually rich topics, such as those in Mathematics, in an understandable way (Abramovich, 2013). These signifies, in present-days where technology usage is a tradition of the generation, assimilating the teaching and learning with mediums that could catch up and satisfy pupils' interest is of high value. In response to the needs and for the benefits of learners, the web-based instructional tool, GeoGebra, has been proved to play significant role compared to Khan Academy, IXL, NCTM Illuminations, NLVM, (Little, 2008). The findings of Moeller & Reitzes, 2011) and Velichova, (2011) also underlined that integrating GeoGebra, with mathematics curricula can help to aid satisfaction of students, train students with skills essential for work and provide an active learning experience. From then on, GeoGebra has been developed by vibrant international communities in supporting the teaching-learning of simple to advanced courses in mathematics and related disciplines. The following features also make GeoGebra a preferred tool, to be considered in the teaching-learning process (Escuder & Furner 2011; Majerek, 2014; Velichova, 2011).

Constructive-based approach of the current Mathematics curriculum, teaching and learning mathematics has improved substantially due to accessibility of educational technology (National Council of Teachers of Mathematics, 2003). Confirmations from literature show that teachers who utilize educational technology comprehensively in their Mathematics instruction environment are likely to build high confidence in pedagogical technology skills and focus their lessons on a student-centred approach which improves students' performance in Mathematics (Bos, 2009). Also, Bos pointed out that when technological tools are available in mathematics classrooms, learners can pay attention on reflection, problem solving, reasoning, and decision making.

In this rapidly changing environment, education should change as quickly as the technology does. In today's world, computer-based technology can be considered as one of an important component of any modern curriculum. The continuing challenge is to scrutinize the applications of the instructional technology and to identify whether these tools can give good benefit to students' learning process. According to Fluck (2010), the future of Information, Communication and Technology (ICT) should play as a transformation role in education by integrating it into existing subject areas. The transformative view of ICT in education requires us to examine what new ways of pedagogies and curriculum are appropriate for a new generation working with new tools.

In Ghana, major investment in ICT has been implemented to achieve effective teaching and learning in the classroom. Ministry of Education (MOE) has over the years seen the application and the use of ICT in mathematics education. For that purpose, Government of Ghana has launched several mega projects which could employ the use of ICT during teaching and learning. These efforts by the Ghana MOE are also in line with The National Council of Teachers of Mathematics' (NCTM) Principles and Standards for School. According to NCTM (2000), technology is essential in teaching and learning mathematics where it can influence the mathematics that is taught and enhances students' learning. Besides that, technology can also help students to furnish their visual images of mathematical ideas, organizing and analyzing data, and can compute efficiently and accurately. Technology can support students to investigate in every area of mathematics, such as geometry, statistics, algebra, measurement and number (NCTM, 2000).

The effect of technology usage in Mathematics classrooms on students' performance has drawn the attention of Mathematics educators to the need to utilize technological software in mathematics classrooms.

In view of this, the Mathematical Association of Ghana (MAG) has made a remarkable step towards the use of ICT in the teaching and learning of Mathematics which will be an effective tool for social transformation (Suleman, 2012). The Association is of the view that teaching and learning Mathematics with technology will aid students to visualize, think, reason, analyse and articulate logically. The use of the computer makes it suitable for teachers to design lessons which make learners become more interested and eager to study and enjoy Mathematics (Suleman, 2012).

Other Literatures had shown that the advancement of computer has brought great innovation and thus school teachers need Bos be competent in using computers so that they would maximize its use in teaching and learning (Kumar, Rose & D'Silva 2008). In addition, Nik Azis (2008) distinguished that the use of ICT has to be integrated in Mathematics Curriculum in both formal and informal ways and not just make it as an extra component. By integrating ICT into their everyday teaching practice, teachers can provide creative opportunities for supporting students' learning and fostering the acquisition of mathematical knowledge and skills (Hohenwarter & Hohenwarter 2009). When technological tools are available, students can focus on decision making, reflection, reasoning, and problem solving. Students can also benefit in different ways from technology integration into everyday teaching and learning. For example, Hollebrands (2007) highlighted that new learning opportunities are provided in technological environments which potentially help students to engage with different mathematical objects and level of understanding. ICT also adds a new dimension to the teaching and learning of Mathematics by helping students to visualize certain mathematics concept (Voors, 1999). Voorst (1999) and Hohenwater & Hohenwater (2009) claimed that the visualization and exploration of mathematical objects and concepts in multimedia environments can foster understanding in new ways.

Secondary school mathematics is designed to help students in working out solutions to problems with accuracy, precision and speed both academic and functional life situation. The core mathematics syllabus at Senior High School (SHS) level in Ghana is made up of the following content domains: Numbers and Numeration, Plane Geometry, Algebra, Vectors and Transformation in a Plane, Statistics and Probability, Trigonometry and Mensuration (Ministry of Education, 2010). Geometry, which is the main focus of this study places emphasis on circle theorems. Geometry is a branch of mathematics that provides a rich source of visualization for understanding arithmetic, algebraic, and statistical concepts (Drickey, 2001 January 14). As such, the teaching and learning of geometry is very essential in everyday life since it provides a more complete appreciation of the world we live in. The reason being that it appears naturally in the structure of the solar system, in geological formation of some rocks and crystals, in plants and flowers, and even in animals (Lie & Hafizah 2008).Circle theorems is considered as a very important aspect of geometry. Its application is seen in ship navigation. According to Ministry of Education (2010), the objectives of teaching and learning circle theorems at the Senior High School level are that students should be able to find:

i. the value of the angle subtended by a diameter at the circumference.
ii. the relationship between angles in the same segment produce by the same cord or circumference
iii. the relationship between the angle subtended at the centre and that at the circumference by an arc.
iv. the relationship between opposite angles of a cyclic quadrilateral.
v. the relationship between the tangent and the radius or diameter at the point of contact.
vi. the relationship between the angle between the tangent and cord at the point of contact and angle in the alternate segment.
vii. the relationship between two tangents drawn from an external point to the circle.

With the advent of technology, various readily available technological tools were designed and used for educational purposes (Heid, 1997). The continuing challenge is to scrutinize the applications of the instructional technology and to identify whether these tools can give good benefit to students' learning process. In math education, computers have raised the importance of certain ideas, made some problems and topics more accessible, and provided new ways to represent and handle mathematical information, affording choices about content and pedagogy that we've never had before. From the perspective of teaching mathematics, technologies such as educational software, interactive whiteboards and computers are integrated into classroom use to provide more comprehensive learning opportunities for students (Öçal & Şimşek 2017). As software, Computer Algebra Systems (CAS) and Dynamic

Geometry Environments (DGE) are considered as two important examples among modern educational technologies especially for teaching mathematics (Botana, & Abánades 2014). Both software categorized as CAS and DGE have wide variety of applications in teaching mathematics and helpful tool for students' understanding of mathematics subjects. Advantages of effective use of any of this software in classroom environment were mentioned in the previous literature excessively (e.g., Erbas & Yenmez 2011; Furner & Marinas, 2007; 2002; Kabaca 2006; Öçal & simsek 2017). For example, CAS software packages such as Derive, Mathematica and Wolfram Alpha enable students to do mathematical computations with mathematical symbols. Some examples also provide students with graphical or tabular demonstrations of algebraic computations and step-by-step solutions for them (Kabaca, 2006). These software packages provide students with enriched learning environments to discover mathematical ideas and theories (Artigue, 2002; Kabaca 2006). On the other hand, software packages with the features of DGE such as Cabri Geometry, Geometer's Sketchpad and Cinderella are useful tools for students to visualize mathematical structures, concretize its abstract nature, and construct link between algebra and geometry (Hohenwarter & Jones 2007). Considering the fact that same mathematical structure may vary or be perceived differently in different contexts, the properties of DGE software packages enable students to see the differences and comprehend the reason-result relations in various contexts, and observe them from multiple perspectives, especially with its dragging property (Hohenwarter & Jones 2007). They also allow students to explore both algebraic and geometric representations of the same mathematical structures (Hohenwarter & Fuchs 2004). Therefore, they can make connections between different forms and explore how any change in one form of any mathematical structure influence its other forms.

In addition, students can do modeling activities, so they can construct and understand relation between real life and abstract mathematical structures and concepts studied (Hohenwarter & Fuchs 2004: Pierce & Stace 2011).In recent years, a software package called GeoGebra is widely used in mathematics classrooms (Aydos 2015; Öçal & Simsek, 2017; Shadaan & Leong 2013; Tatar & Zengin 2016). The prominent feature of Geogebra is that it combines the properties of both CAS and DGE in a single software package (Hohenwarter & Fuchs 2004). This software allows users to see the algebraic, graphical and spreadsheet forms of any mathematical objects at the same time (Hohenwarter & Jones 2007). Therefore, using GeoGebra promotes students' meaningful and conceptual understanding of intended mathematics topics. In addition, mathematics education researchers provided evidences that effective use of GeoGebra supported and had positive impact on students' conceptual understanding and performances in wide variety of mathematics topics including geometry (e.g., Samur, 2015), analytic geometry (Zengin & Tatar 2016), algebra (Healy & Hoyles 2002), and calculus (e.g., Aydos 2015; Tatar & Zengin 2016; Kepceoğlu 2010).

In math education, computers have raised the importance of certain ideas, made some problems and topics more accessible, and provided new ways to represent and handle mathematical information, affording choices about content and pedagogy that we've never had before. Many mathematics software have been introduced and widely practiced all over the world, such as Geometer's Sketchpad (GSP), Autograph, Maple, Matlab, Mathematica and so on (Kamariah, Ahmad & Rohani 2010). These tools have been proven to be a very important aspect in the teaching and learning process. For example, Rohani et al. (2010) has showed the importance of Autograph, educational software which can be used by students to change and animate graphs, shapes or vectors already plotted. This activity can stimulate students' interest, encourage understanding of concept and further understand mathematical phenomenon in real life. There are various types of commercial software available for teaching and learning Mathematics in the open market. For example Geometer's Sketchpad, Derive, Cabri, Matlab, Autograph and others. These mathematical softwares have been used in schools and universities worldwide. Teachers need to purchase those software in order to use it in the classroom which some of the software is really costly. However, there are softwares that could be freely used by educators in classroom teaching. The term Open Source Software (OSS) allows user to download any software that is available and suitable for the users. Until August 2010, there are more than 240,000 software projects that have been registered in SourceForge.net which is the world's largest open source software development site (SourceForge.net, 2010). Software which are similar to OSS and related to mathematics instructions such as SAGE, FreeMat, Maple, GeoNet, JLab, Maxima, Axiom, YACA learning.

There is awareness of our students' poor performance in Mathematics as evidenced by the results of trends in International Mathematics and Science Study (TIMSS), which was conducted in 2003, when the results were ranked from highest to lowest in performance, Ghana occupied the 44th Position out of 45 participating Countries. The result is very painful to those of us who brag about the Ghanaian prowess. Brooding over the results is of no use though; rather concrete steps must be taken to stop the downward trend of performance in Mathematics, stabilizing the situation and then gradually move the whole Nation towards understanding and appreciating the beauty and utility of Mathematics in today's World (Adentunde, 2007).

Evidence from the West African Examination Council's chief examiner's report on West African Senior School Certificate Examination in core mathematics has for several years unearthed candidate's difficulties in solving problems involving geometry such as, cyclic quadrilaterals, tangent and chord theorems (West Africa Examination Council [WAEC], 2017). (Abreh Owusu & Ameadahe 2018; Kalhotra, 2013; Sa'ad Adamu & Sadiq 2014) Studies into the causes of these abysmal performances of students in mathematics especially WASSCE in the sub-region, have identified inappropriate or poor teaching strategies employed by mathematics teachers, poor entry grades and school factors such as lack of facilities as some of the causes. Adegun & Adegun (2013) stated that students in general find difficulties in solving geometry tasks and their performance is always poor in the senior high school mathematics exercises or tests. Also, Telima (2011) found out that many students fail to understand the major geometrical concepts especially circle theorem and leave mathematics classes without acquiring the basic skills. Fabiyi (2017) also found out in his study that circle theorem, coordinate geometry and construction were the most perceived difficult topics in geometry by senior high school students.

Students showed high level of difficulty in identifying angles subtended at the centre and at the circumference by an arc. Moreover, in questions relating to angles subtended by a diameter at the circumference majority of the students encountered difficulties in the area of recognizing the theorem to be used as well as writing the correct mathematical statements. How well students retain taught circle theorems concept can be traced back to the teachers' teaching approach used in class.

The pursuit of mathematics is therefore, vital and imperative for any society, or community or nation in order to maintain its independence and ensure increased prosperity and keep its place amongst the civilize nations (society) of the world is this era of technology. The rich and more advanced country of the world have attained their affluence through advanced which they made in mathematics which links sciences and technology. This implies that mathematics education is a very important input in the scientific and technological development of any society. It is now obvious that mathematics subject is a tool for science and technology (Adentunde, 2007).

The teaching system is complex, made up of several elements mutually interacting around the three poles: the teacher, the students and the knowledge. The teaching/learning trend has been changed due to the development of technology in the last few years. The factors that influence students' attitudes towards Mathematics are the teaching materials used by teachers, classroom management, teacher content knowledge and personality, relating the topics with real life situation (Yilmaz, Altun & Olkun, 2010) and teaching methods (Papanastasiou, 2002).

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.

Several reports of the West African Examination Council (WAEC) indicate that students who write WASSCE have been performing poorly in Circle Theorem questions (WAEC, 2017). Very often, students avoid questions on Circle Theorems when they have other alternatives. On rare occasions, most of the few who attempt questions on this topic display nothing but their lack of knowledge in the subject matter (Fletcher & Anderson 2012). In the May/June 2017 Mathematics examination, the Chief Examiner for Mathematics states that question 8 (a) posed a serious problem to candidates who attempted it (see. Figure 1.1). Most candidates who answered the question in part (a) demonstrated that their understanding of geometrical concepts was woefully inadequate because they could not solve for <RMS. They could not apply the cyclic quadrilateral theory and other geometrical principals to solve the problem. Candidates were unable deduce from the diagram that angles subtended by a chord $\overline{RS}$ in a segment are equal (WAEC May/June, 2017.8a).

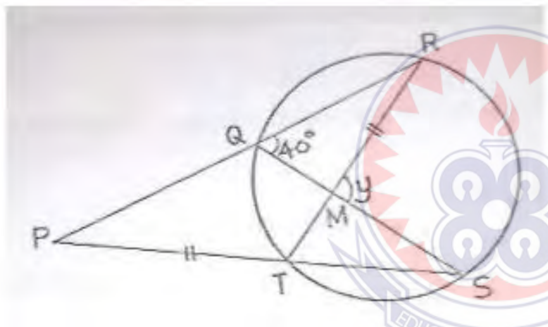

Figure 1.1 WASSCE May/June 2017 Question 8(a)

In support of this, Chief Examiner's Report of WASSCE (2016) also points out that majority of the candidates could not solve for < RST (see figure 1.2). The answers provided by candidates to part (b) of the question revealed their lack of knowledge in geometry as such most candidates performed poorly in answering the question. Candidate could not apply the geometric concepts of isosceles triangles, a line which is tangent to a circle and the relationship between interior and exterior angles of a triangle. The report adds that the performance of students on this question was not encouraging (Waec May/June, 2016 2b)

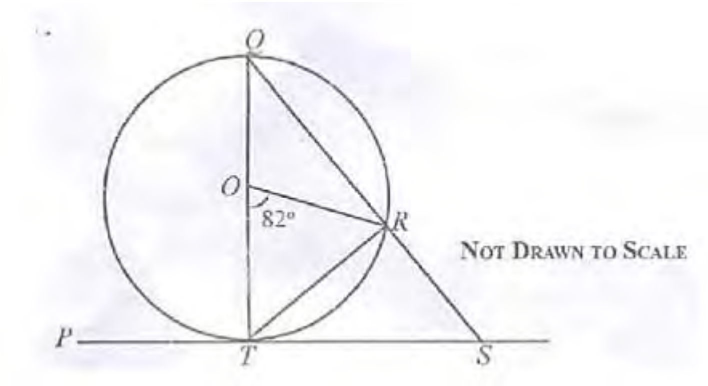

Figure 1.2 WASSCE May/June 2016 Question 2(b)

These learning difficulties the students faced when learning Circle Theorems were due to the fact that learning environment in most Ghanaian classrooms is dominated by traditional teaching approach teachers usually adopt in their classrooms. This teaching approach is mainly dominated by the teacher. In this teaching and learning environment, the teacher is mostly an information giver instead of being a facilitator and the students are recipients of knowledge, instead of negotiator of Mathematics concepts.

A number of authors, including Johnston-Wilder & Mason (2005), have also blamed students' lack of interest and understanding of Geometry on teachers' poor teaching skills and lack of resources for presenting geometrical shapes to students. Johnston-Wilder, S. and Manson (2005) argued that the ordinary primary tutor has an anxiety of the very word 'geometry.' One suspects, therefore, that it is difficult to encourage any form of geometry to be taught at all in primary schools, and some books for primary teachers devote little time or space to it. Pupils who proceed to the senior high school, therefore, have very weak foundation in Geometry in general and Circle Theorems in particular. Perhaps, one of the reasons why so much time is spent on arithmetic than on Geometry in the primary school is that skills and techniques in arithmetic are very much more in evidence.

With the dominance of traditional methods in Mathematics instruction in Ghana coupled with students' learning difficulty in Circle Theorems, one probable approach for enhancing instruction and student learning could be implementing realistic instructional method such as the use of GeoGebra.

The Traditional method of teaching makes students' passive listeners and deficient in geometrical analysis and reasoning. Also, this approach to teaching and learning Geometry lays more emphasis on how much a student can remember and less on how well the student can think and reason, and it makes the teacher dominate the classroom and turns students to mere listeners (Mereku, 2010). For these reasons, students are not encouraged to discuss, interact with each other and to explore the content collaboratively, and repeatedly fail to build the exploration and visualization skills demanded for geometrical ideas, geometry reasoning and problem-solving skills. Therefore, this discourages students from learning Geometry, which leads to poor performance as noted by Battista (2007) and Idris (2006).

While it is promising to see that several previous studies have demonstrated positive effects of GeoGebra instructional approach lessons on students' achievement, a reading of the literature available indicates that many of these studies are not centered on GeoGebra instructional approach in teaching and learning Circle Theorems as a sub-topic under Geometry, particularly in Ghana. Also, the findings of the study point out the challenges teachers faced in teaching Geometry to lack of resources to teach Geometry, its abstract nature and inability of students to visualize geometrical images. Therefore, it is the aim of this study to determine the effects of using GeoGebra as an instructional tool in teaching Circle Theorems on performance of SHS 2 students.

This will enable students visualize geometric images in GeoGebra interface and discover properties about circle geometry.

The researcher used mixed method design to investigate "the effect of using GeoGebra, on acquisition of concepts in circle Geometry" among fifty- one third year Senior High School (SHS3) of 2018/2019 academic year in Anloga District of Volta Region of Ghana. The Students were divided into an experimental (A) and a control group (B). The experimental group was taught using GeoGebra software while students in the control group were instructed through traditional teaching approach.

Pre-test, post-test, and guided interview were the main data collection instruments the researcher adopted. The results were analyzed using Descriptive statistics, pair sample T test, and independent t test in IBM SPSS version 25.

1.2 Statement of the Problem

As part of National Pre-tertiary Education Curriculum Framework, the Government of Ghana in collaboration with Ministry of Education has made provisions to ensure that Senior High School (SHS) students gets access to quality education which takes into account the integration of ICT in education through Accelerated Development (ICT4AD) policy that seeks to provide framework for transforming Ghana into information-rich, Knowledge-base and Technology-driven high-income economy and society. It is in this regard that the education Reform of 2007 advocates for the integration of ICT into education to facilitate effective teaching and management through the provision of computer labs, internet and network productivity, the supply of school laptops to teachers and learners and the capacity development of teacher. The curriculum therefore proposed ICT use as a pedagogical tool (MINISTRY OF EDUCATION [GES Syllabus], 2018). ICT has currently become a compulsory (core) subject for every SHS students in Ghana and this has led to the sudden increase in computer laboratories at all levels of our school system and this testify the potency of the use of computer technology in education delivery (Asiedu-Addo & Yidana 2000).

Several reports of the West African Examination Council (WAEC) indicate that students who write WASSCE have been performing poorly in geometry (Circle Theorem) questions (WAEC, 2012). Very often, students avoid questions on geometry (Circle Theorems) when they have other alternatives. On rare occasions, most of the few who attempt questions on this topic display nothing but their lack of knowledge in the subject matter (Fletcher & Anderson 2012).

In the May/June 2011 Mathematics examination, the Chief Examiner for Core Mathematics states that question 3 (a) posed a serious problem to candidates who attempted it (see. Figure 1). They could not recall the appropriate Circle Theorem property and relations to answer the question (WAEC, 2011).In the chief examiners report, it is obvious that most students lack the properties of similar triangles in coordinate geometry(WAEC, 2014).

Again, the chief examiners report of WAEC (2016) stated that, candidates' weaknesses were shown in area of circle theorems and their applications in solving problems in geometry. According to WAEC (2016) most students displayed a large mass of difficulty in solving problems involving geometry and trigonometry. For many years the failure rate of students in mathematics and geometry has been on the ascendency in Senior High Schools.

Evidence from the West African Examination Council's chief examiner's report on West African Senior School Certificate Examination in core mathematics has for several years unearthed candidate's difficulties in solving problems involving geometry such as, cyclic quadrilaterals, tangent and chord theorems (West Africa Examination Council [WAEC], 2017). Studies (Abreh, Owusu & Ameadahe, Falhotra 2018) into the causes of these abysmal performances of students in mathematics especially WASSCE in the sub-region, have identified inappropriate or poor teaching strategies employed by mathematics teachers, poor entry grades and school factors such as lack of facilities as some of the causes. Adegun & Adegun 2013) stated that students in general find difficulties in solving geometry tasks and their performance is always poor in the senior high school mathematics exercises or tests. Also, Telima (2011) found out that many students fail to understand the major geometrical concepts especially circle theorem and leave mathematics classes without acquiring the basic skills. Fabiyi (2017) also found out in his study that circle theorem, coordinate geometry and construction were the most perceived difficult topics in geometry by senior high school students. Akyeampong, Lussier, Pryor & Westbrook(2013) confirmed in their studies that students' in Senior High School have difficulties in answering similar problems in circle theorem. Students showed high level of difficulty in identifying angles subtended at the centre and at the circumference by an arc. Moreover, in questions relating to angles subtended by a diameter at the circumference majority of the students encountered difficulties in the area of recognizing the theorem to be used as well as writing the correct mathematical statements. How well students retain taught circle theorems concept can be traced back to the teachers' teaching approach used in class. Moreover, in questions relating to angles subtended by a diameter at the circumference majority of the students encountered difficulties in the area of recognizing the theorem to be used as well as writing the correct mathematical statements. How well students retain taught circle theorems concept can be traced back to the teachers' teaching approach used in class

Furthermore, the Chief Examiners report of WAEC (2018), revealed that most students could not solve question four (b) (see figure 2) because they have insufficient knowledge in properties of cyclic quadrilateral.

Furthermore, there is empirical evidence that many students in Ghana face difficulties in solving questions involving geometry concepts (Baffoe & Mereku, 2010). This suggests that SHS students find geometry concepts difficult and mathematics teachers are faced with the challenge of how to present geometry concepts to students to promote conceptual understanding. As a result, the methods of teaching mathematics should be of great importance to mathematics educators. Generally, teaching requires that, the teacher creates an environment in which students are active learners. Unfortunately, mathematics teachers in sub-Saharan Africa use the traditional method of teaching in their lessons where concepts are taught by giving a set of rules to students to be followed without the students knowing how those concepts came about (Akyeampong, Lussier, Pryor, & Westbrook, 2013). According to Wood & Gentile (2003), educators are beginning to recognize that there are better ways to learn other than through the traditional methods. This will help guide students to explore and visualize Mathematics, especially geometrical concepts. The use of ICT in education permits learners to involve in certain cognitive activities such as carrying out scientific procedures, studying natural phenomenon through simulation, looking up information, analyzing data and solving real life problems (Anamuah-Mensah,Mereku & Asabere-Ameyaw, 2004).

However, despite the impact of educational technology and strong advocacy for the need to utilize ICT in the teaching and learning of mathematics, classrooms in Ghana are still characterized by traditional method of teaching. The traditional method is the teaching approach characterized by lecture/oral exposition (chalk and talk).In addition information gathered by the researcher reveals that teachers in the district still use traditional or teacher centred method to teach circle theorems. Traditional or teacher centred method makes students passive, act as spectators in the learning process, does not enhance critical thinking and collaborative problem-solving. Also, the traditional method of teaching does not enhance critical thinking and collaborative problem-solving since "chew and pour" is the order of the day. Students should be exposed to skills in creating their own knowledge in order to enhance understanding of mathematical concepts rather than providing them with a set of rules without understanding.

In order for students to perform better in circle theorems, teachers should use student centred method such as Geogebra teaching approach. Consequently, students' achievements and problem solving skills in mathematics and specifically geometry has been on the decline and has not seen any appreciable improvements over the years.

In discharging our duties in the classroom as mathematics teachers, we often encounter a lot of problems faced by learners. These problems sometimes discourage students in their learning of mathematics and eventually cause their failure in the subject. One of such problems identified among SHS students in Keta Municipal is the inability of students to solve problems in circle theorem due to the traditional teaching method teachers use regularly in the classroom.(Zormelo, 2016).

Students have difficulties in solving problems in circle therem in the other two SHS in Anloga District but for the lack of time the researcher couldn't do extensive research into the problem; the researcher recommends that, subsequent research should be carried out into the effect of Geogebra learning tool on acquisition concepts in circle theorem in these two Senior High schools in Anloga District (Zormelo, 2016).

From the above-mentioned findings, couple with the chief examiners report, it's obvious that circle geometry is among the topics that requires serious attention. It is however, unfortunate to note that there has been minimum comprehensive research study to employ Geogebra teaching tool on achievement of students in circle theorem in Anloga District.

This study therefore, sought to investigate the effectiveness of Geogebra teaching tool on the acquisition of concepts in circle geometry in Anlo senior high school in Anloga District in Volta Region in Ghana.

1.3 Purpose of the Study

The purpose of the study was to investigate the effectiveness of Geogebra teaching tool on the acquisition of concepts in circle geometry by Senior High School Students in Anloga District in Volta Region in Ghana.

1.4 Objective of the Study

The objectives of this study are to:

1. Investigate the causes of poor performance of students in circle theorem.
2. Investigate the impact of traditional teaching method on the academic performance of students in circle theorem.

3. Investigate the effect of GeoGebra teaching tool on students' achievement in circle theorem.

1.5 Research Question

The study is designed to investigate the effects of dynamic Geogebra software, on the acquisition of concepts in circle theorem by Senior High School Students in Anloga District in Volta Region in Ghana.

The study sort to answer the following questions:

1. What are the causes of poor performance of students in circle theorem?
2. What is the impact of traditional method on the academic performance of students in Circle theorem?
3. What is the effect of GeoGebra learning tool on students' achievement in circle theorems?

1.6 Hypothesis

To determine the effect of using GeoGebra teaching tool over the traditional method as instructional tools in the teaching of Circle Theorems on the performance of students, the following hypotheses are formulated to guide the research questions of the study.

H_0: There is no significant difference in the mean scores between students utilizing GeoGebra tool and traditional instruction.

H_1: There is significant difference in the mean post scores between students utilizing GeoGebra tool and conventional instruction.

1.7 Significance of the Study

1.7.1 Students

The study will enable students identify properties of each circle theorem. It will improve the conceptual understanding and skill Development of students in circle geometry. It will also help students to acquire the needed skills to improve their achievement in circle geometry.

1.7.2 Teacher

The study will help mathematics teachers to use GeoGebra tool to help students identify properties in each circle theorem. The study will also help mathematics teachers to be aware of how to use GeoGebra tool to improve the conceptual understanding and skill development of students in circle theorem. Mathematics teachers will be furnished with which teaching approach to employ in classroom that will motivate students, to learn circle theorems. The study will help students to change their perception on circle theorems. The study will encourage them to develop positive attitude towards learning of circle theorems at Senior High School level which will contribute to a higher achievement in mathematics.

1.7.3 Mathematics Educators

The findings of this study would provide relevant literatures to mathematics educators and researchers who wish to undertake future research into effect of Geogebra on achievements of students in circle geometry.

In the light of the literature review and the lack of the research in the field, this study will be conducted by considering its significance in teaching and learning of mathematics, that is, contribution to mathematics education. Thus, this research study will provide insight into the effects of geometry environment on students'

Mathematics Achievement in Circle theorem. The findings of the study may shed light on the design of technology-supported learning environment and instructions. Also, the information derived from this study can serve as foundations for development of curricular considerations.

This study may also lead to subsequent research studies on new teaching methods or supportive components to the existing teaching methods based on the results to find an answer to the question of "How do we teach mathematics better?" Findings of this study may be also significant in validating the usage of dynamic geometry software while teaching by employing Dynamic Geometry Software Assisted Instruction.

The result of the findings would also serve as a resource material for policy developers and planners in designing an enriched course manual or model on the effective ways of using Geogebra in the teaching and learning of Mathematics.

Findings of the study can also serve as the basis for organizing professional development courses and in-service training programs for teachers on the effective use of Geogebra to teach topics under geometry.

The study would make teachers in the mathematics departments give attention to the use of ICT and software in the teaching and learning of mathematics especially in Geometry. It will also help teachers to appreciate and realize the importance of using Geogebra software in teaching circle geometry.

The study is also expected to contribute to the following:

1. This study is a response to modern trends, which calls for the employment of technology in teaching, so as to overcome the shortcomings and disadvantages

of the traditional way in the various courses of study, and in the course of mathematics in particular.

2. Shed light on the potential role of the Geogebra software in the development of the academic achievement and in acquiring some visual thinking skills.
3. Draw the attention of those in charge of the educational process to the role of the effective Geogebra software.
4. It might be useful to Mathematics teachers in the development of teaching and evaluation methods.
5. The current study may open new avenues to researchers to conduct future studies in the use of new technological innovations in the educational process in the different stages of teaching and various educational courses.

1.9 Limitations of the Study

The present study has some limitations. Firstly, subjects (maths teachers for the interview) were not assigned to the experimental and the control group randomly. Besides, the results of the study were limited to the population with similar characteristics. Furthermore, duration of the treatment was three weeks. This duration was short in gaining evidence regarding the improvement of students' achievement in circle geometry.

This study was restricted to the topics of Circle Geometry only. Only SHS three students were involved in the study. Hence, this limited focus restricted the generalization of the results of the study to other contents in mathematics. In addition, the results of the study were limited due to the instruments used to measure certain variables. Thus, different results could be obtained if different instruments were used.

The Covid 19 protocols could not permit larger class size. And Funds were not available to purchase hand sanitizer and nose Mask for all students regularly.

1.10 Delimitation of the Study

Two classes were selected for the study. Researcher regularly gave and checked homework. In this study the researcher has used GeoGebra teaching tool. Researcher, himself taught using GeoGebra Software and a different teacher taught using traditional instruction.

1.11 Definitions of the Important Terms

Geogebra learning (teaching) tool(aid) is a teaching method that makes use of a computer software which enables students and teachers to visualize geometric figures and shapes, explore geometric relationships and concepts, make and test conjectures in a dynamic learning environment by manipulating the objects such as dragging, constructing, rotating, translating in order to understand the concepts of geometry (Goldenberg & Couco, 1998). In this study, GeoGebra was used to teach the subject of transformational geometry. This based on the delivery of the activities and tasks using Dynamic Geometry Software. In this learning environment, the teacher gives students instructions about the dynamic activities and tasks after a brief explanation about the topic while students explore the relationships between the concepts and draw conclusions through these activities and tasks. In this study, the experimental group students were taught with geogebra teaching tool using the dynamic GeoGebra activities and tasks.

Traditional Method of Teaching: The traditional method of teaching for the purpose of this study is a teacher-centric method that promotes the supremacy of the teacher within the classroom setup. Here teachers followed the drill and rote method of memorization. In this method, children learn through repetition and memorization.

It is also the process by which mathematics teachers explain concepts to students by using board illustrations and then follow the explanations up with examples from textbooks. It refers to a teacher-centered, textbook-based teaching approach. It includes teaching through lectures, note-taking, question-answer and exercises. In regular learning environments, the teacher acts as a knowledge transmitter and sometimes asks questions to the students. Rules, definitions, strategies and generalizations related to the topic are given first, and then examples are provided. The students are passive listeners and note-takers in this learning environment (Duatepe, 2004). In this study, the control group students were taught using traditional teaching approach.

Achievement is defined as “something accomplished successfully, especially by means of exertion, skill, practice or perseverance” (Thorndike & Barnhart, 1993, p. 46). In this study, achievement means the total measurement of the scores of mathematics achievement test. In another words, the achievement is what the MAT measures.

Attitude is defined as “those beliefs formed from a combination of experiences measured in the domains of mathematics” (Capraro, 2000, p. 8). In this study, attitude means the total measurement of the scores of attitude towards mathematics scale. In short, attitude is what the MTAS measures.

Attitude towards mathematics and technology refers to student's self-reported enjoyment, interest and level of anxiety toward learning mathematics with technology (Pilli & Aksu, 2013).

1.12 Organization of the study

This study covers five chapters. Chapter One comprises of the introduction and addresses the background, statement and purpose of the study, research objectives, questions, hypothesis, significance of the study as well as limitations and delimitations of the study. A review of the literature is presented in Chapter Two and addresses the theoretical and conceptual framework and other relevant research findings pertaining to the topic. The methodology used in this study is described in detail in Chapter Three and includes the research design, population, sample size, sampling technique,validity,collection of data, treatment of data and ethical consideration. Findings and discussion, data analysis of results, is provided in Chapter Four,where the research questions and hypotheses are addressed. Finally, Chapter Five includes a summary of findings from the study, the researcher's conclusions and recommendations.

CHARPTER 2

LITERATURE REVIEW

2.0 Overview

This chapter reviewed related literature relevant to the study. The important areas covered include: Theoretical framework, conceptual framework, Concept of geometry and circle theorem, Causes of poor performance of students in geometry and circle theorems, Suggested ways for teachers to teach geometry and circle theorem to improve students' performance, The concept of Geogebra software, The effect of Geogebra teaching approach on students' achievement, Geogebra software in Math Education, The concept of traditional teaching approach, and lastly, the effect of traditional teaching approach on students' achievement.

2.1 Theoretical Frame work

In this study, GeoGebra teaching tool and traditionl teaching methods are based on Vygotsky's social constructivist perspectives, because knowledge is actively constructed by students while they are making construction and analyzing figures instead of knowledge being passively received and accepted (Vygotsky, 1978). With the Zone of Proximal Development (ZPD), in the learning of circles, the more skilled students were able to assist their peers with information and manner of constructing diagrams and the more capable students were able to fill in gaps in their peers" knowledge or explanations they have missed (Vygotsky, 1978). The peers then gain a different insight and develop a different manner of understanding circle concepts. In addition, when working in groups due to the differing ZPD of each student, they may have differing views; therefore, through interaction with peers they can achieve shared understanding (Vygotsky, 1978). However, in such a situation, there must be a balance in terms of the insights and ideas contributed by each group member; it is important to have shared views and justifications of opinions to reach mutual understanding. This enables all students to participate in critical thinking skills because one's cognitive development becomes apparent when new views and ideas are taken into the current cognitive state(Vygotsky, 1978). The main principles will anchor on the zone of proximal development (ZPD) and scaffolding. Students generally have challenges in understanding mathematical concepts; therefore, in this study the GeoGebra software was introduced as a scaffold to enhance student understanding of circles (Vygotsky, 1978).

The ZPD is described as the variance between one's mental age and the level one might attain in problem solving with guidance. Scaffolding refers to the guidance provided for one to reach the ZPD (Vygotsky, 1978). In this study the GeoGebra software and the traditional teaching method used basically acts as the primary scaffold in assisting and guiding the students to reach their ZPD. The students were required to work in pairs to construct diagrams and make observationsbased on their constructions. Students formed their own interpretations through shared understanding with the guidance of the GeoGebra where they were able to explore and visualize on their own. On top of that, the teacher and peers also played a part in the scaffolding process.

In conclusion, a constructivist classroom may contain the following four characteristics

(a) Cognitive exploration to encourage inquiry and direct hands-on, minds on activities.

(b) Student autonomy where students are in charge of their own learning.

(c) social interaction where students work together in groups with opportunities for cognitive conflict; and

(d) Student-centered where students' ideas and opinions are important. In this respect, it can also be concluded that the teacher's role here is more of a facilitator. Fig 2.1 below shows the conceptual framework of ZPD.

Fig 2.1 ZPD AS THEORETICAL FRAMEWORK

2.2 Conceptual Framework

The conceptual framework of this study is based on Vygotsky ZPD and two scaffoldings illustrated in Fig 2.2 and 2.3 below. The study has made significant used of social interctions among students to attain their shared level of understanding.

Social interaction between peers gave the students opportunities to guide one another and reach a level of shared understanding. Here the higher ability students play a big role in helping the lower ability students to reach their ZPD. The higher ability students also benefit through the new ideas and views of their peers (Vygotsky, 1978). According to (Vygotsky, 1978) learning is an active contextualized process of constructing knowledge. Knowledge is constructed based on personal experiences and hypothesis of environment. Vygotsky's views are closely related to this learning environment where he emphasized that social interaction and cultural environment contribute to cognitive development. However, this must take place within the zone of the individual's potential development. In this study, students were placed in groups where the scaffolding process can take place for them to construct circles based on what they already know and with help accepted from their peers when **needed and Technology; in this respect the GeoGebra software was an important scaffold to bridge the ZPD.** In this environment the teacher acts as a facilitator. This manner of learning enhances critical thinking skills as students contribute ideas and views to reach a common understanding. However, this process had to be closely monitored to ensure a balance in terms of input from both group members. After this collaborative process, every student self-explores knowledge of circle with in intra-psychological as well as inter-psychological. GeoGebra gave the students an opportunity for peer interaction to enhance understanding and visualization of the concept of circles.

Fig 2.2 and Fig 2.3 below indicates how the ZPD and Scaffolds conceptual framework is used in both Geogebra and traditional environment respectively to achieve the desired objectives.

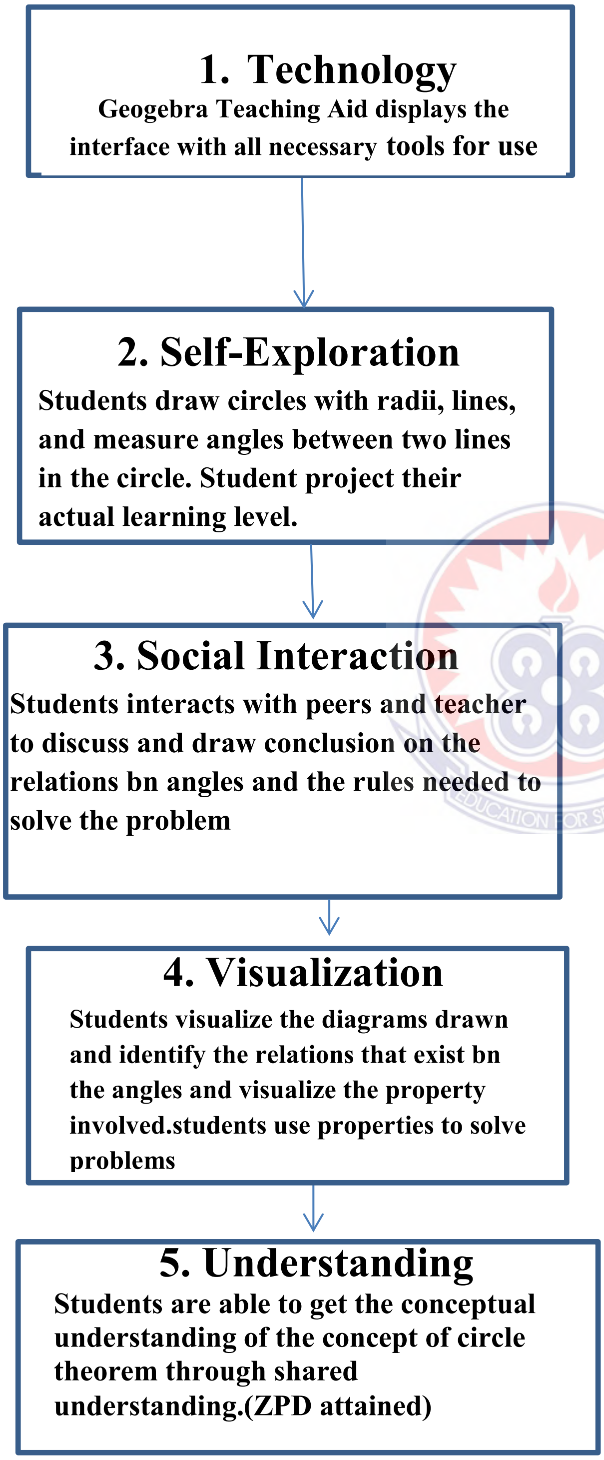

Fig 2.2 TSSVU (ZPD IN GEOGEBRA LEARNING ENVIRONMENT)

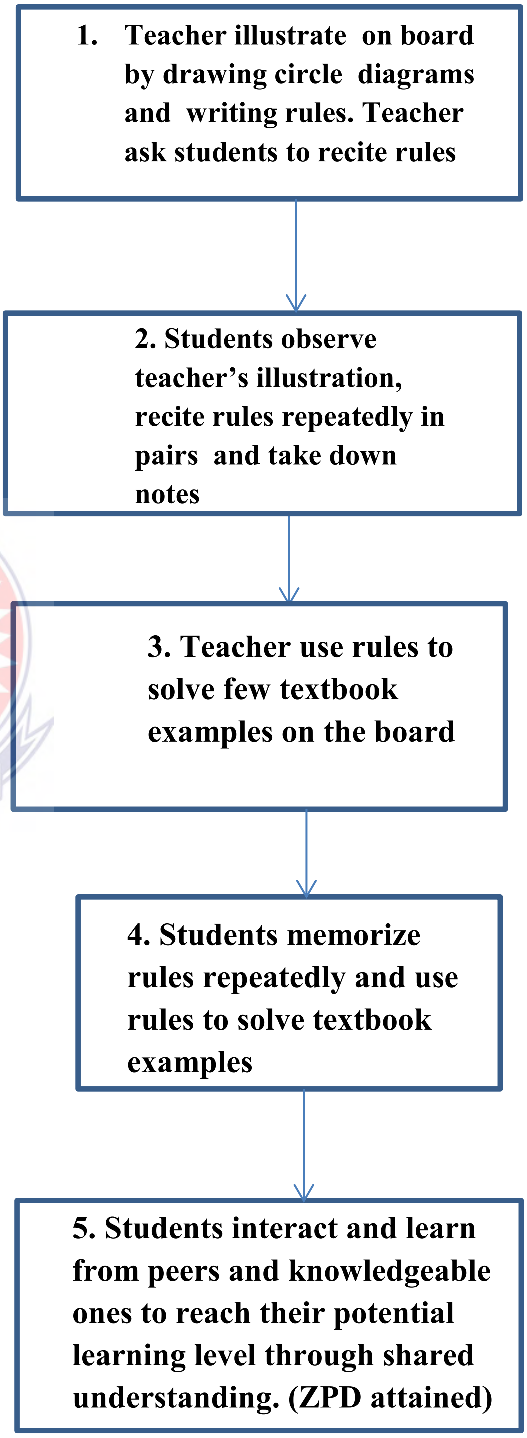

Fig 2.3 ZPD IN TRADITIONAL TEACHING ENVIRONMENT

2.3 Concept of Circle Theorem (Geometry)

According to Hohenwarter, Kreis & Lavicza (2008), GeoGebra is a computer program (software) for Mathematics, especially for learning geometry, algebra, calculus, statistical, etc. Abramovich (2013) defines GeoGebra as a free online software application for the study of geometry, algebra, and calculus at grade level and different teaching. Studies on students' perception on applying technology in Mathematics classes were given less attention (Li, 2007).

Geometry is fundamental course of mathematics which is use in early primary grade to higher classes. GeoGebra have powerful and user-friendly capability to understand, explain and visualization of geometrical concepts (Battista, 2009). .

Geometry is defined as "it examines figures and their movements" in the elementary mathematics curriculum (Battista, 2009). It is stressed in the curriculum that while the geometrical thinking is developing also knowledge acquired in geometry activities have to provide visual and analytical reasoning and inference with a hierarchical order within the required attention respectively. The results of student's reasoning with intuition are called conjecture. Producing information via inference called conclusion, although very few students may produce information via inference. It is also highlighted that while the students achieve targets about related areas of geometry, special attention and importance should be given for processing of specific skills, affective features, psychomotor skills and self-regulation

Geometry has been defined by various scholars; "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, 2009). 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. According to (Clements & Battista, 1992) "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 difficult to learn and teach. This is because spatial ability is not easy for all students. Complications experienced in teaching and learning of Geometry as sited in the second handbook of research on mathematics teaching and learning, Battista (2007), include: i) Conception affects perception since what one sees is affected by what one knows and conceives. ii) Diagrams as data or representations. It is through analyzing the geometrical diagrams that concepts are derived. The diagrams used in mathematics are representations of the actual object. In teaching the concepts of geometry therefore, the teacher is faced with the task of helping learners 'see' the objects represented in the image and further derive some meaning from it.

2.4 Causes of Poor Performance of Students in Geometry and Circle Theorems

A number of factors have been put forward to explain why students perform poorly in geometry and circle. Findings made by Noraini (2006); Aysen (2012) have shown that some factors are identified to make the learning of geometry concepts in mathematics difficult which include: teachers' methods of instruction, geometric language, visualizing abilities. Fabiyi (2017) found out that the reasons given by students for perceiving a geometry concept difficult includes: unavailability of instructional materials, teachers' method of instruction and so on. Chappell (2003) claimed that high school students' less desirable background in geometry was due to basic school mathematics teachers' superficial geometry knowledge. Other studies by Duatepe (2000) and Halat (2008) argued that pre-service elementary school mathematics teachers' reasoning stages contributes to the problems students encounter in learning secondary geometry concepts. Knight (2006) stated that the elementary school mathematics teachers involved in her study were not at a suitable van Hiele level to understand formal geometry and that their previous instructions had not helped them to attain knowledge of geometry consistent with level – IV of van Hiele postulate. According to Betiku (2001), teachers' content knowledge has a significant impact on students' performance. Mayberry (1983) stated that geometry content knowledge among pre-service and in-service middle school teachers is not adequate. Chappell (2003) said, "Individuals without sufficient backgrounds in Mathematics or Mathematics pedagogy are being placed in middle school Mathematics classrooms to teach" (p.294). The West African Examinational Council (2006) examiners' report showed that questions on geometry topics such as circle geometry were very poorly answered. The same report concluded that teachers did not get adequate support in the area of geometry in their teacher preparation programme. Thus, they went into the field with the same challenges that they had when they were students themselves in schools. The quality of instruction is one of the greatest influences on the students' acquisition of geometry knowledge in Mathematics classes. According to Akyeampong, Lussier, Pryor & Westbrook (2013) mathematics teachers in sub-Saharan Africa use the traditional method of teaching in their lessons where concepts are taught by giving a set of rules to students to be followed without the students knowing how those concepts came about. Traditional approaches in learning geometry emphasize more on how much the students can remember and less on how well the students can think and reason. Thus, learning becomes forced and seldom brings satisfaction to the students (Baffoe & Mereku, 2010). The problem with traditional instruction is the concept of rote learning. Marshal (2006) took the definition of "rote" from the Oxford English Dictionary as, a mechanical manner, by routine; especially by the mere exercise of memory without a proper understanding of, or reflection upon, the matter in question. Through traditional mathematics instruction, children are expected to use a mathematical concept before they have been able to experience it primarily focusing on how the teacher told them how to use it. This style of teaching is what Battista (2009) as cited by Marshal (2006) described as ineffective and seriously stunts the growth of students' reasoning and problem-solving skills. Studies done by Al-ebous (2016) had shown that the teachers' method of teaching geometry and their personality greatly accounted for the students' positive attitude towards geometry and that without interest and personal effort in learning geometry by the students, they can hardly perform well in the topic. Mogari (1999), propounded that conventional wisdom and some research suggest that students with negative attitude toward geometry have problems with understanding other concepts in geometry simply because of anxiety. Also, Geddes & Fortunato (1993) noted that students attitude about the value of learning geometry may be considered as both an input and outcome variable because their attitude towards geometry can be related to educational achievement in ways that reinforce higher or lower performance Pickens (2005) linked higher achievement in geometry to positive attitude on the part of the students. Charles & Lynwood (1990) stated that the mortality in high school geometry has traditionally been high and this has been ascribed to various causes such as the difficulty of the subject, ineptitude or laziness on part of the student and many more. While Rukangu (2000) have held that students lose interest in geometry because of its abstract nature which they regard as having no practical value, Charles, B. & Lynwood (1990) argued that demonstrative geometry is not easiest subject to learn. Charles & Lynwood (1990) continued and said it demands careful and sustained attention, perseverance and a measure of ingenuity; in order to attain a real mastery of Geometry topics.

Charles & Lynwood (1990) further reported that the real reason for much of the failure in geometry and apathy towards Geometry lies mainly in poor motivation and failure to provide clear insights into the meaning and methods of the subject, they also assert that children will work hard at things that interest them and they delight in games and puzzles. Rukangu (2000), studied pupils' development of spatial ability on Mathematics and found that 67% did not enjoy learning spatial concepts because they are confusing, abstractly demanding a lot of thinking and difficultly to understand. To overcome this, Rukangu (2000) recommended that the teacher should understand, encourage and motivate their pupils. However, Mulwa (2014) on the other hand observed that reading Mathematics textbooks provides students with opportunity to learn the language and vocabulary necessary to improve their language competence hence better performance in Geometry. Mulwa (2014) argued that Mathematics required understanding of concepts and constant practice to internalize them. In his study, the teachers unanimously agreed that many English words can easily confuse students because they carry different meanings in the normal language usage from mathematical usage. For instance, words like volume, normal line, bearing, elevation, deduce, perpendicular, among others were identified. Adegun and Adegun (2013) stated that students generally encountered difficulties in geometry and performed poorly in senior secondary school mathematics lesson. Also, Telima (2011) found out that many students fail to grasp key concepts in geometry and leave mathematics classes without learning the basic terminology. Consequently, research findings have 26 confirmed that geometry is one of the topics among the abstract and complex aspects of mathematics that students find difficult to learn (Akinlade, 2004). For a topic like geometry which is the bedrock of engineering and technological development, the issue of adequate physical facilities cannot be over emphasized. The physical facilities such as models will help grasp the idea of geometry which seems to be abstract. It is the facilities in terms of infrastructure, equipment and materials that afford the students the opportunity to acquire the necessary knowledge. As Betiku (2001) observed on a general note, that secondary schools lack facilities and equipment for teaching. According to Betiku (2001), such a situation where teachers are forced to discuss theoretically, practical aspects of the subject is not good enough.

2.5 Suggested Ways to Teachers to Teach Circle Theorem

The methods used in teaching Mathematics are instrumental in determining ones performance (Keith, 1999). Farrant (1997) argues that instructional methods contribute towards success in subject teaching. Mathematics teaching at all levels should include opportunities for exposition by the teacher, discussion between the teacher and the pupils and between the pupils themselves and appropriate practical work consolidation. It should also involve practice of fundamental skills and routines of problem solving (Morris, 2001; Cockroft, 1982). One objective of learning geometry that is considered critical is the development of deductive reasoning. Jones, Fujita, and Ding (2006) discussed about teaching and learning approaches in geometry and suggested that applying geometry through modeling, deductive reasoning, development and use of conjecture, problem solving in a range of contexts, creating awareness of the historical and cultural heritage of geometry in society, as well as the contemporary applications of geometry should be encouraged in learning geometry. They established with the suggestion that instruction in geometry should encourage students to engage in investigative activities, demonstrative creativity, and making discoveries in geometrical contexts so that students develop their powers of spatial thinking, visualization and geometrical reasoning. Since the activities used in learning geometry are meant to develop certain objectives, students learning geometry are expected to exhibit certain skills in geometry. Kiminza (1999) in a study undertaken by Kenya Institute of Education (K.I.E), found out that Mathematics teachers mainly use participatory teaching approach. In Kiminza (1999) analysis of most frequently used methods, assignment method scored 50.6% followed by a class discussion 48.6%, demonstration 38.9%, drawing and modelling 34.4%. According to Kiminza (1999) participatory teaching method was prevalent despite the deteriorating performance over the years. The learning of Mathematics (geometry) is often viewed as an isolated, individualistic or competitive matter; one sits alone and struggles to understand the material or solve the assignment problems. This process can often be lonely and frustrating (Davidson, 1990). This can lead to “math avoidance” or “math anxiety” (Awanta, 2004; Sofowora, 2014). Davidson (1990) observed that small group cooperative learning could solve lonely and frustrating problem of learning mathematics (geometry). Small group provide a forum in which students ask question, discuss ideas, demonstrate to others, learn to listen to others and offer constructive criticism and summarize their discoveries in writing. Rukangu (2000) in his study on pupils’ development of spatial ability in Mathematics observed that one of the students’ study habits was discussion between students and students, between teachers and students and between students and parents. Mathematics teachers in secondary schools provide students with worked examples of sample problems or use the ones provided in the textbook with the hope that students will determine the underlying principle or rule that govern the solution of the initial problem and transfer the learning to a new problem. According to Mayer (1992) and Horn (1995), students face the obstacles of inability to understand why the underlying rule worked correctly in the given example and are unable to use the underlying rule on a new problem. Horn (1995) advised teachers to give adequate varied worked examples with various complexities; plan a series of worked examples and that students should work out similar examples immediately. This enhances students' achievement and ability to transfer learnt concepts to new mathematical problems. Students can solve new problems by using what they already know from analogous problems. According to Rose and Arline (2009), students demonstrate conceptual understanding when they use diagrams. Therefore, the use of diagram in learning geometry involves learning to recognize the visually relevant graphical invariant information attached to a geometric drawing. In an explanation of the importance of activities in students learning geometry, Clements, and Battista, (2000) examined studies that discussed activities and children's thinking in geometry. Clements and Battista (2000) came to the conclusion that children are better prepared for all school tasks when they gain the thinking tools and representational competence of geometric and spatial sense. Some activities focused on students, as part of learning geometry, developing certain skills such as a specific way of thinking, understanding relationships, and developing spatial reasoning. Sdrolias and Triandafillidis (2008) discussed geometric activities that involved the use of manipulatives in learning geometry concepts. Sdrolias and Triandafillidis (2008) focused on the teaching of geometry as students' transition from primary to secondary school in the Greek educational system and engaged participants in tasks which involved the use of manipulatives. Sdrolias and Triandafillidis ((2008) found from their analysis that the teaching approach of the teachers observed impacted the logical steps that lead to rigor in secondary school as reflected in the responses from student activities used. As Sdrolias and Triandafillidis (2008) compared data over the three year period, they noted that consistency and accuracy are stripped from children's past experiences from primary school. Sdrolias and Triandafillidis (2008) concluded this trend implies that the transition to secondary school geometry and mathematics in Greece may not encourage the construction of mathematically more developed sign.

The use of technology in the learning environment not only helps education for maintaining in accordance with the necessities of the era, but also provides individuals with opportunities for growing adequately (Ersoy, 2003). The power of new technologies as one of the strongest forces in the contemporary growth and evolution of mathematics and math teaching are technology and technological advances which obviously affect how we learn and teach mathematics (Goldenberg, 2000). It is the common viewpoint of educators that the existing problems related to the teaching cannot be solved by using the traditional teaching methods (Aktümen & Kaçar, 2003). As Usiskin (1982) and Fuys, Geddes & Tischler (1988) promoted, the role of instruction is crucial in teaching and learning geometry. The more systematically structured the instruction, the more helpful it will be for middle school students to overcome their difficulties and to increase their understanding of geometry. Hence, the common opinion of many researchers, mathematics teachers, and studies focus on the notion that the novelties in mathematics education and technology integration into mathematics education support students' understanding of mathematics, and they suggest the use of technology in mathematics classrooms

(Hollebrands, K. 2003). Furthermore, the mathematics education researchers have a parallel interest in investigating the effect of technology on learning and teaching mathematics, and the curriculum. Technology tools provide powerful range of visual representations which help teachers to focus students' attention to mathematical concepts and techniques (ZbiekZbiek, Heid, Blume & Dick, 2007). Thus, technological tools, such as Computers, Graphic Calculators, Interactive White Boards, Web-Based Applications, Dynamic Mathematics/Geometry Softwares, are started to widely use in mathematics classroom and many studies investigated to determine the effectiveness of technology in mathematics education (Baki, 2001; Dogan, 2010; Ersoy, 2003; Hollebrands, 2003; Koehler & Mishler, 2005; NCTM, 2000).Technology environments allow teachers to adapt their instruction and teaching methods more effectively to meet their students' needs (NCTM, 2008). By integrating educational tools into their everyday teaching practice, teachers can provide creative opportunities for supporting students' learning and fostering the acquisition of mathematical knowledge and skills. Parallel with the awareness of the increasing importance of new technologies in everyday life, several educational organizations started to develop technology related standards (Lawless & Pellegrino, 2007), trying to encourage the integration of new technology in learning environments. For instance, the National Council of Teachers of Mathematics (NCTM, 2008), which is the world's largest association of mathematics teachers considered technology as one of their six principles for school mathematics and continues: 'Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning.'(p. 11)

Computers are one of the mainly used technologies in learning environments. Increasing load of information, instruction process that is being more complicated day by day, and the purposes and standards of quality and contemporary education mandated the use of computers in education (Baki & Güveli, 2008). In order to win the race in the road of modernization, almost all countries enhanced their efforts of utilization of computers in all fields, especially in educational field. Computers as the most favorite tools of the 21st century affect human life and society. First and foremost, computers bring innovations and radical changes to education systems with bringing to other fields of the countries (Mercan, Filiz, Göçer & Özsoy, 2009). Computers are extremely crucial since they can provide a variety of rich experiences that allow students to be actively involved with mathematics (McCoy, 1991). In mathematics teaching, computers have fostered entirely new fields. As to educational field, they've raised the importance of certain ideas, made some problems and topics more accessible, and provided new ways to represent and handle mathematical information, affording choices about content and pedagogy that we've never had before (Goldenberg, 2000). Moreover, the computers offer students immediate access to the web, where they can find additional resources and use interactive sites to investigate mathematical concepts. Over the years, the computers have become vital for business and economy and 'computer literacy' is considered a very important skill in modern-era society. Especially for young people who have grown up having access to computer technology at home, computers have become common tools for communication, text processing, and last but not least, playing games. As in many other fields, computers were started to utilize in educational field through learning environments. On the one hand, successful students can be supported more effectively than ever by nurturing their individual interests and mathematical skills. On the other hand, weaker students can be provided with activities that meet their special needs and help them to overcome their individual difficulties. Thusly, students "may focus more intently on computer tasks" and "may benefit from the constraints imposed by a computer environment" (Preiner, 2008). Moreover, the development and rapid growth of the Internet in combination with its increasing accessibility for the public has opened up a whole new digital world (Ersoy, 2003). Technological advances which we face in the era we live in and the approach of Computer-Assisted Instruction had effects also on the mathematics teaching in the schools (Akkoç, 2008). The use of computers in classrooms has been expanding, in part, owing to the positive effects of Computer-Assisted Instruction of mathematics (Souter (2001). Thus, millions of schools around the world started to utilize Computer-Assisted Instruction in the learning environments. There are many studies which indicate the positive effect of Computer-Assisted Instruction on students' mathematics learning (Çoban-Gökkaya, 2001; Helvacı, 2010; Tayan, 2011; Sulak, 2002; Şataf, 2010; Şen, 2010) Computer-Assisted Instruction can be defined as a method of utilization of computers in learning environments which aims at making students' recognize their own deficiency and performance through mutual interaction, control their learning with getting instant feedbacks, and making students more interested in lesson by the help of graphics, audio, animations and figures. The mathematics teaching that is done by utilizing the cognitive tools based on the computers is defined as Computer Assisted Mathematics Instruction (Baki, 2002). Computer-Assisted Mathematics Instruction have been started to be important in terms of forming learning environments in the field of mathematics education (İpek & İspir, 2011). Since 1950s, many countries, firstly in Italy, then United States of America, initiated studies for extending the computer-Assisted instruction by integrating it into their curricula (Mercan, Filiz, Göçer, & Özsoy, 2009). The purpose of giving computers place in the learning environments is to grow productive, creative, successful, critical thinker, problem solver and adequate individuals in order to improve certain knowledge, skill and attitude. Thus, all of these goals may be fulfilled by utilizing the computers in the teaching learning process (Aktümen & Kaçar, 2003). Ersoy (2003) conducted a study on the use of computers and calculators in teaching and learning mathematics to contribute in developing strategies and developments in mathematics teaching process. The results of his study showed that the students need to understand how to use technology tools in their learning experiences. When integrated properly into the teaching and learning process, computers improve student proficiency in mathematics. Through different software applications, computers reduce the cognitive load of mathematical learning (Kozma, 1987; Liu & Bera, 2005). As a supportive tool, interactive mathematics computer programs such as Geometer's Sketchpad (Jackiw,1995) and virtual modeling and visualization tools also provide students with dynamic multiple representations and support their understanding as they interact with concepts in a variety of ways (Flores, Knaupp, Middleton & Staley, 2002; Garofalo, Drier, Harper, Timmerman, & Shockey, 2000). Additionally, students can develop and demonstrate deer understanding of mathematical concepts and are able to cope with more advanced mathematical contents in technology-enriched learning environments than in 'traditional' teaching environments (NCTM, 2008). Students can benefit in different ways from technology integration into everyday teaching and learning. New learning opportunities are provided in technological environments, potentially engaging students of different mathematical skills and levels of understanding with mathematical tasks and activities (Hollebrands, 2007). By the help of the visualization of mathematical concepts and exploring mathematics in multimedia environments, students' understanding in a new way can be fostered. Van Voorst (1999) reported that technology is useful in helping students view mathematics less passively, as a set of procedures, and more actively as reasoning, exploring, solving problems, generating new information, and asking new questions. Furthermore, he claims that technology helps students to visualize certain math concepts better and it also adds a new dimension to the teaching of mathematics. Laborde, Kynigos, Hollebrands, and Strasser (2006) summarized technology use in mathematics education as following; "(…) Research on the use of technology in geometry not only offered a window on students' mathematical conceptions of notions such as angle, quadrilaterals, transformations, but also showed that technology contributes to the construction of other views of these concepts. Research gave evidence of the research and progress in students conceptualization due to geometrical activities (such as construction activities or proof activities) making use of technology with the design of adequate tasks and pedagogical organization. Technology revealed how much the tools shape the mathematical activity and led researchers to revisit the epistemology of geometry" (Laborde et al., 2006, p. 296)

2.6 Concept of Geogebra Teaching tool

Geogebra Teaching tool is a mathematics software which was created by Markus Hohenwarter in 2001 at University of Salzburg, Austria. In this study, the Open Source Software (OSS) GeoGebra was selected from the available software packages for mathematics teaching and learning. GeoGebra spftware is free open-source dynamic software for mathematics teaching and learning that offers geometry and algebra features in a fully connected software environment. GeoGebra software is the combination between Computer Algebra System (CAS) which provided visualization capabilities and Dynamic Geometry System (DGS) which provided dynamic changeability (Lu, 2008). It was designed to combine features of dynamic geometry software (e.g. Cabri Geometry, Geometer's Sketchpad) and computer algebra systems (e.g. Derive, Maple) in a single, integrated, and easy to-use system for teaching and learning mathematics,(Hohenwarter & Lavicza, 2009). This dynamic mathematics software program was created by Markus Hohenwater and now has been translated to 40 languages. Users all over the world can freely download this software from the official GeoGebra website at http://www.geogebra.org. Research on the effectiveness of integrating GeoGebra in teaching and learning mathematics still limited.

The visualization of Algebra Window and Geometry Window provides a connection between algebraic and geometric representations. In Geometry Window, points can be moved along function graphs, parameters are changeable using sliders, and text adapts automatically to changes (Hohenwarter et al., 2008**)**. GeoGebra should be able to ease teachers' burden if the teachers are ready and committed to learn on educational software teaching. The application of this software can help to build a fun learning environment where students can explore the mathematical concept differently compared to conventional teaching. GeoGebra able to build chart, graph, tangent and angles easily and very convenient as the instructions are provided and shown in the menu bar. The color of the background and different colour on certain words in GeoGebra window can help in emphasizing mathematical concepts. Besides, it can help the students to focus on lesson. Many advantages of GeoGebra are found especially in mathematics visualization (Hohenwarter et al., 2008; Kamariah et al., 2010a, 2010b). This software is much easier to deal with compared to Mathematica and Maple which requests programming and coding skills. By using the GeoGebra, teacher can experience some changes in teaching and learning mathematics. However, research on other dynamic geometry software can offer effective impact in mathematics education and has the potential to promote student-centered learning and active learning. Furthermore it can enhance students' ability in visualizing the mathematical elements hence improving learning (Hodanbosi, 2001; July, 2001; Mohammad, 2004; Ahmad, Ahmad, Kamariah & Rohani, 2010).

Below are interface and snap shots from Geogebra classic software.

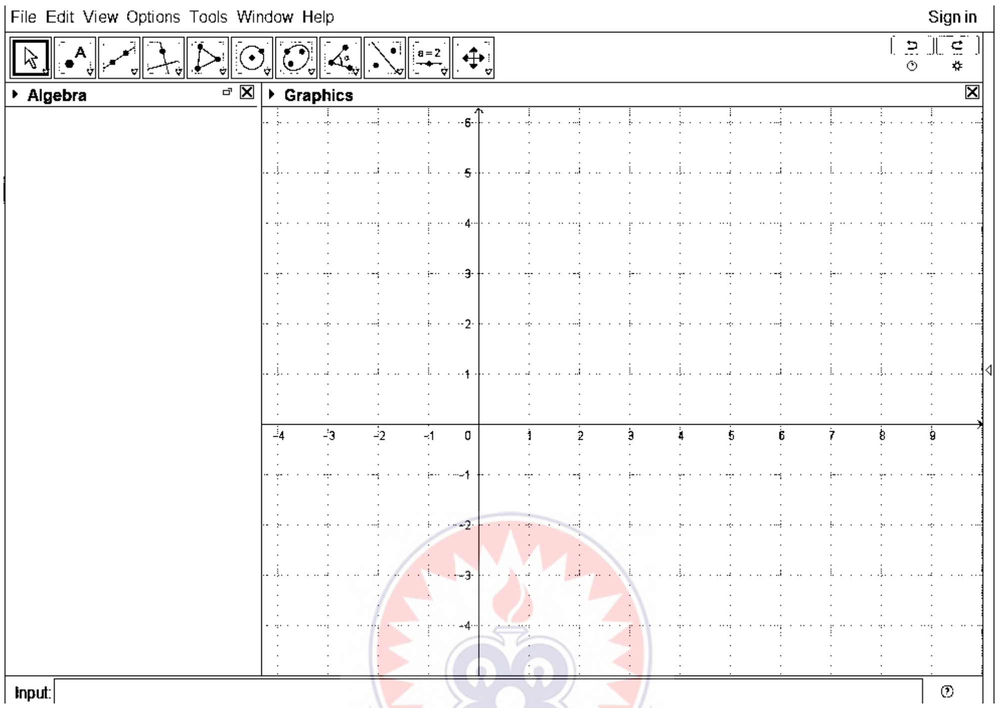

Figure 2.4: Example of interface of Geogebra.

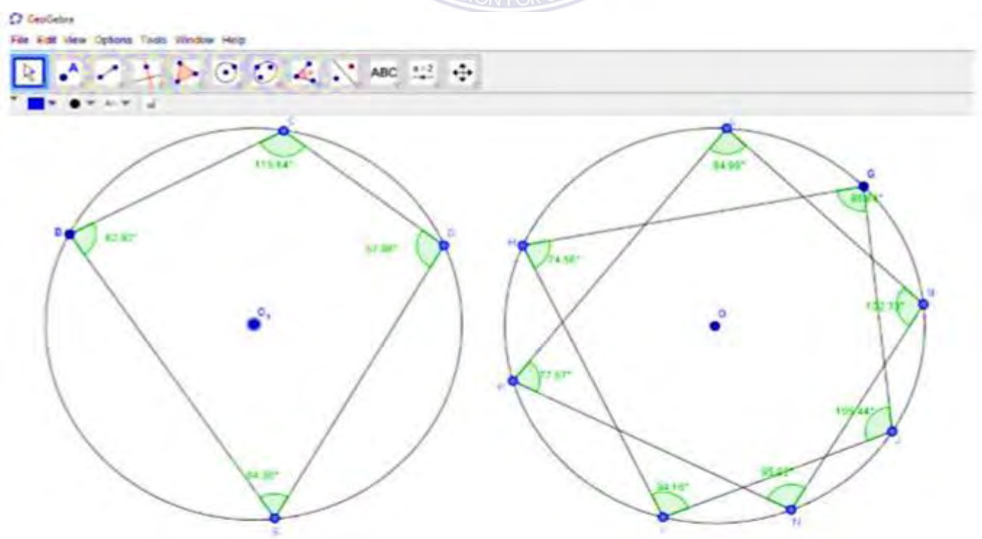

Figure 2.5: Example of snap shot from GeoGebra Software

The suggestions for use of GeoGebra in senior High school level as educational software tools. It is an emergent open-source Dynamic and Interactive Mathematics Learning Environment (DIMLE) for teaching mathematics for all stages. The advantages of use of Geogebra are given as follows:

1. In comparison to other mathematics related software like Mathematica, Mapple etc. Geogebra is easy to use.
2. In comparison to Graphics calculator Geogebra is more user friendly.
3. It offers easy-to-use interface, multilingual tool, commands and help menu
4. It facilitates to make dynamic applets to make activity by basic skill of programming.
5. Users can personalize their own creations by customization. That is, they can change font size, line thickness, color and other styles etc.

2.7 Effect of Geogebra Teaching Tool on Students' Mathematics Achievement

There are many research studies indicating that GeoGebra enhance students' academic achievement. Some of these studies were mentioned in this section. One of these studies was conducted by Bilgici and Selçik, (2011) with 32, 7th grade students from two different schools to investigate the effects of GeoGebra in the learning of the Polygons on 7th grade students' mathematics achievement. The experimental group (17 students) were taught by Computer-Assisted Instruction using several GeoGebra worksheets prepared, while the control group (15 students) were taught in a computer-free learning environment for 11 teaching hours in a primary school. The experimental group received instruction of GeoGebra for 2 hours before the treatment is implemented. Results of the study revealed that the difference between the experimental and the control groups after the treatment is statistically significant. This result indicates that Computer-Assisted Instruction utilizing GeoGebra enhanced students' achievement scores more than the Computer free Instruction did. It was also found that the experimental group students carried out more effective learning with Computer-Assisted Instruction utilizing GeoGebra and retained what they learnt more than they retained after they learned via computer-free instruction. As a result, the researchers concluded that the use of DGS in mathematics education enhanced students' mathematics achievement and retention level more than the traditional method did per se. In another research, Saha, Ayub and Tarmizi (2010) studied with 53 secondary school students to investigate the effects of GeoGebra on mathematics achievement in the learning of Coordinate Geometry. The sample of the study was assigned into two groups as high visual-spatial ability students (HV) and low visual spatial ability students (LV) according to the Spatial Visualization Ability Test. Results of the study revealed that there was a significant difference between the control group and GeoGebra group in favor of the GeoGebra group related to the mean performance scores. The results of study also indicated that there was no significant difference between the high visual-spatial ability (HV) students taught with GeoGebra and the high visual-spatial ability (HV) students taught with Traditional Instruction in terms of the mean posttest performance scores. The results of study also showed that there was no significant difference between the low visual spatial ability (LV) students taught with GeoGebra and the low visual-spatial ability (LV) students taught with Traditional Instruction in terms of the mean posttest performance scores. This finding showed that LV students who had undergone learning Coordinate Geometry using GeoGebra was significantly better in their achievement rather than students underwent the traditional learning. In other words, the study results showed that the GeoGebra enhanced the LV students' mathematics performance in Coordinate Geometry. Consequently, the results of this study revealed that Computer-Assisted Instruction (using GeoGebra) as a supportive tool to the Traditional Instruction is more effective than Traditional Instruction per se. Similarly, Zengin, Y., Furkan, H., and Kutluca, T.(2012) conducted a study to determine the effects of dynamic mathematics software GeoGebra on 10th grade students' achievement in trigonometry. The sample of the study consisted of 51, tenth grade students. The experimental group students were undergone to the lessons arranged with the GeoGebra in Computer-Assisted Instruction, while the students in control group were taught with constructivist instruction. The data collected after 5 weeks of the application. The test results indicated that there was a significant difference between the experimental and the control groups' achievement scores in trigonometry. This difference was in favor of the experimental group which had lessons with GeoGebra. Parallel with the study results Zengin, Furkan, and Kutluca (2012), İçel (2011) conducted a study to analyze effects of dynamic mathematics software GeoGebra on eight grade students' achievement in the subject of triangles. The sample of the study consisted of 40 (20 in experimental group and 20 in control group), 8th grade students. The experimental group students were instructed with the planned activities that were constructed with GeoGebra, while the control group students were taught with traditional method in accordance with the official curriculum textbook for six class hours, two weeks in total. A pre-test (consisted of 13 questions), a post-test and a recall test were administered to the groups both before and after the treatment to collect data. The post-test and recall test, which consisted of 11 questions, were identical. The recall test was administered to the students one month after the study completed. Results of the study revealed that the experimental group students scored higher on the post-test than the students in the control group. The total recall test results showed that GeoGebra was also effective in enhancing the permanence of the acquired knowledge. The students in the experimental group scored higher on the recall test than the students in the control group. Zengin (2011) also carried out another experimental quantitative study with 51 students at the high school level to determine the effect of GeoGebra on both achievement and attitude toward mathematics. The researcher designed GeoGebra workshops for the experimental group and used a pretest posttest control group design. Similar to the study of İçel (2011), it was found that GeoGebra has a positive effect on mathematics achievement. However, there was no significant difference between the experimental and control group in terms of their attitudes towards mathematics (Zengin, 2011). Filiz (2009) conducted a quasi-experimental study with 25 elementary school students (12 in treatments and 13 in control group) to investigate the effect of using GeoGebra and Cabri Geometry II Dynamic Geometry Softwares in a Web-based setting on students' achievement and the development of learning experiences during this process. For this purpose, four objectives of 8th grade geometry learning field were selected and a web site including dynamic geometry softwares and worksheets related with the subject were prepared for the students. As a result of the study, a significant difference was found in favor of the treatment group in which web-based materials were used. Moreover, it was found that a more effective learning is experienced by students taught with web based learning materials when compared to students taught with Traditional Instruction. The results of the study also revealed that dynamic geometry softwares improved students' inference and hypothesizing skills.

2.8 Concept of Geometry teaching tool in Mathematics Education

Tecnology has revolutionized the world and the affairs of man in general, the teacher and learner in particular. It has in no small wise influenced teaching and learning and has equally altered the conventional role of both the teacher and learner, a paradigm shift from a teacher-centred to a learner-centred learning environment, hence the emphasis placed on learning rather than teaching. The latest definition of educational technology lead credence to this claim as a core element of its domains is "facilitating learning" (AECT, 2010).

In this world of globalization, many mathematics software have been introduced and implemented as a computer-support learning to help students to be actively thinking about information, making choices, and executing skills compared to conventional teaching (Rohani etal. 2010). The use of technology can help to enhance understanding of abstract mathematical concepts by enhancing students' visualization or graphic representation on relationships between objects and their properties. Many studies showed that there is an improvement on students' achievement when GeoGebra is implemented in mathematics teaching and learning process (Royati et al., 2010).For example, Zengin, Furkan and Kutluca (2012) have reported that a general high school in Diyarbakir has showed a significant difference between mean performance scores of the control group compared to GeoGebra group when the GeoGebra software was integrated in the teaching and learning process for three weeks**.** Royati et al. (2010) showed that GeoGebra instruction is more effective than the traditional instruction alone in teaching Geometry Coordinate topic. The finding of the study showed that the low visual-spatial students in the GeoGebra group significantly outperformed the low visual-spatial students in the control group. Another study by Kamariah Abu Bakar et al. (2010a) also showed that the GeoGebra and another open source software, E-tranformation have helped to improve students'mathematics achievement.Students' motivation in understanding mathematical concepts are enhanced too with technology implemented (Kamariah Abu Bakar et al., 2010). Rohani et al. (2010) have investigated the cognitive factors enhanced with the integration of interactive software Autograph in comparison to the conventional way for teaching Calculus at the secondary level. Their findings showed that integrated learning strategy is instructionally more efficient compared to the conventional instruction strategy. This was because Autograph users able to change and animate graphs, shapes, or vectors in understanding a concept. This study shows promising implications for the potential use of Autograph software as a tool in teaching mathematics at Malaysian secondary school level.

Besides that, Harizon (2005) found that the perception of the teachers and students towards using computer and Geometry software in teaching and learning mathematics was highly positive. A study conducted by Kor and Lim (2009) found that the students enjoyed GSP class and they felt that the GSP lesson was interesting. Student can concentrate to the teaching and learning process because they can visualize mathematical concepts clearly, can get engaged in mathematics learning by GSP due to its visual abilities and animation. The integration of GSP in teaching and learning of mathematics also has gained positive responses from teachers (Kasten& Sinclair, 2009). Furthermore, graphic calculator is also popularly used in teaching and learning mathematics nowadays. It helps students to think the procedural knowledge such as what information to enter, what operation to use and finally ways to interpret the result in order to solve mathematics problems besides using it (Nor'ain, 2006). Hence, it developed students' understanding of mathematical concepts without losing their procedural knowledge. Basically, it is hard to see the changes of slope and y-intercept on a graph paper when the coefficient is changed. However, students could graph linear systems by using graphic calculator and can see the changes. In short, the finding showed the graphing calculators increased student understanding of linear equations. From these studies, it was found that students able to understand the concepts better when they are actively engaged and motivated via technology. However some studies showed that the control group performed better compared to the experiment group. For example, Nurihan (2005) showed that there was no significant mean difference in post test scores between students in experimental group and control group. And surprisingly, the mean scores of control group is even clearly better than experimental group. This was because two periods of treatment lesson was insufficient enough to make an influence on students' performance. This result is in the line with a study conducted by Rohani et al (2009) on integrating the Autograph technology for learning Form Four Algebra.

2.9 Concept of Traditional Teaching Approach

The traditional teaching approach is the teaching environment where the teacher is viewed as the pivot in the classroom, responsible for all actions and guaranteeing that all classroom message goes through him or the deductive strategy for instructing (Singh, 2004). It is a conventional technique in which the focus is on content. In this, the teacher remains more dynamic, more subjective and less affective (Singh, 2004). Traditional teaching techniques are concerned with the review of true information and mainly disregard higher levels of rational outcomes (Rao, D.2001). Teaching strategy works against the normal working of the human mind (Weber, 2006). Students are involved in repetitive learning. Teacher forces the students to repeat the material that has been told to them. Corporal punishment, hatred of the teachers and the frightening role of a commanding teacher is noticeable generally in our classrooms. During the long use of traditional teaching periods, interests and consideration of learners can't be looked after (Cangelosi, 2003). It is a teacher-focused technique in which a lot of tension is laid on the course materials and procedurals rather than the learner. Haghighi, Vakil and Weitba (2005) describe traditional teaching strategies as being teacher-arranged, in a speech style and are firm. Lessons are typically directed by the teacher presenting skills utilizing a blackboard joined by a verbal clarification or lecture. According to reformers, traditional teacher-centred techniques concentrated on repetition learning and tend greatly toward class address book knowledge through repetition and retention of actualities, equivalences and formulas. Recitation as a general rule comprises repeating without tending what the book or teacher has communicated. The teachers are ignorant of the current investigations in the field of dialect educating. The part of the instructor inside the class is a dictator with the 45 minimum contribution of the learners (Behlol, 2009). The traditional teaching technique comprises primarily conveying addresses by the teacher and pupils are mentally dynamic, however, physically sit without moving. Learners might be involved in note-taking (Haghighi et al., 2005). In classroom teaching-learning sessions, the main physical task done by the students is either note-taking or remaining on the seat to answer any inquiry of the teacher. There is no way for learners to present their view in the class or talk in the class, and thus pupils get to be inactive learners. It makes the entire procedure of showing learning dull and dry. It provides no room in any movement to the educator and the learners. A disadvantage of this technique is that students who have learning problems persist throughout the lesson without solution.

2.10 Effect of Traditional Teaching Approach on Students' Achievement

With the push for different approaches of mathematics instruction in schools one might think it would be hard to find an advocate for continuing with traditional mathematics instruction. In a study done by Alsup (2003), two different forms of mathematics curriculums; the traditional approach and an inquiry approach were put to the test and compared using students' Scholastic Aptitude Test (SAT) scores over three years. Results showed that the reform method of instruction did not appear to improve significantly over the traditional method. The results also showed that the traditional approach had a positive impact on procedural tasks such as computation and equation solving. After viewing the results, the teacher in whose classroom where the test was administered questioned the time and money spent to implement a reform curriculum and cautioned any mathematics departments from jumping right in. The teacher responded by saying a reform mathematics curriculum is expensive to 46 implements as teachers must be trained and supplementary teaching materials must be purchased to implement the method effectively. Such expenses, in Alsup (2003) opinion, are questionable, since a reform mathematics curriculum did not promote an increase in student achievement (Alsup, 2003). Given these remarks, Alsup (2003) stated the opinion of many current mathematics teachers today by saying that, over the decades, educators have tried to develop more effective methods to teach mathematics. Though most educators agree that mathematics achievement needs to improve, the current reform trend does not appear to be the answer. Further, it appears to be detrimental to procedural knowledge. A major concept in traditional mathematics teaching approach is the idea of spiraling. In traditional mathematics, spiraling is the idea of revisiting a specific mathematical concept several times over some time. It is based on the research of spaced learning which explains that learning is enhanced through stronger memory retention if learning is spaced out over a while (Wartoni, 2005). With the use of spiraling in the traditional mathematics classroom, learner stress is reduced since students are not pressured into fully understanding the mathematical concept being studied the first time, they are introduced to it. With reminders along the way, students can start to assimilate concepts and apply their knowledge to new concepts they will see in the future, progressively getting better at applying the concept and using it. However, the scene Marshal (2006) depicted of a mother and daughter working together on her mathematics sums up what inquiry-based mathematics advocates say is wrong with traditional mathematics. When the mother tells her daughter what the numbers are and has her repeat them back to her it is much like the traditional approach to mathematics instruction. Students learn best when they can make 47 connections, organize, clarify and reflect on their thinking (Burns, 2004) and with traditional mathematics instruction this does not happen.

CHARPTER 3

METHODOLOGY

3.0 Overview

This chapter presents information about the research design, population, sample size,sampling technique, research instruments, reliability, Validity, data collection research procedure, data analysis procedure, and finally, ethical consideration.

3.1 The Research Design

The research design is the detailed plan of the investigation. In this study, mixed method design was used to collect different and complementary data on the same topic for integration and interpretation to address the overall content aim of the study (Creswell & Clark, 2011). This method is justified on the basis that the researcher collected both quantitative and qualitative data within the study period to address the aim of this study. The reason for combining both quantitative and qualitative data was to bring together the strengths of both forms of data for this research work and better understanding of the results (Cohen, 1998: Creswell, 2008).

After the two schools were randomly assigned to the groups, Control Group A for the AGRIC form 3, AG3A class in the first school and Experimental Group B for the Visual Arts form 3, Class VA3A in the second school were used for the purpose of the study.

3.2 Population

Nworgu, (2006) classifies population as target and accessible where target population is all the members of a specific group to which the investigation is related while the accessible population is defined in terms of those elements in the group within the reach of the researcher.

The target population for the study was all the third-year students and mathematics teachers in the public senior high schools in Anloga District in Volta Region of Ghana. There are two public senior high schools, one technical school and one vocational school in the district. The two secondary schools in the district, has a total population of 1320 students in third-year and 36 mathematics teachers in these schools.

3.3 Sample Size

Sample according to Gerrish and Lacey (2010), is a subset of a target population, normally defined by the sampling process. The sample size for the study consists of **two intact classes** of 101(control group = 50, experimental group =51) third year Senior High School (SHS3) students of 2018/2019 academic year and 6 mathematics teachers :3 from each of the two Senior High schools in the District were selected and used for the study.10 students out of 101 students consisting of 5 from control group and another 5 from the experimental group were randomly selected for the interview.

3.4 Sampling Technique

Two intact classes of 101students out of 1320 students consisting of 50 members in control group and 51 members in experimental group of third year Senior High School (SHS3) students was used. Random sampling was use to select two intact classes, one from each school. This technique was used to avoid bias in selecting the classes. **Six teachers** were conveniently selected to provide their reponses on causes of poor performance of students in circle theorem.The selection of both mathematics teachers from the two schools was based on their availability and willingness to participate in the study at the time the interview was conducted and also they taught these studenst in their previous year class.

3.5 Research Instruments

Based on the nature of the research questions examined in the study, Circle Theorems Achievement Test (**pre-test** and post-test) and semi-structured interview were the main instruments used to collect data for this study. The Circle Theorems Achievement Test (pre-test and post-test) was used to collect quantitative data while semi-structured interview was also used to collect qualitative data.

3.5.1 Circle Theorems Achievement Test (ctac)

Circle Theorems Achievement Test was used as an instrument in collecting quantitative data to assess the effectiveness of the experiment on the experimental group. The researcher administered two **tests (i.e., pre-test and post-test).**

The pre-test consists of ten essay type of questions (See appendix B) which were based on core mathematics syllabus objectives 2.7.2, 2.7.3 and 2.7.4 (Ministry of Education Syllabus, 2010) and Core Mathematics Revision Guide 2020 For Senior High Schools Supporting Free SHS (Green Book Pages 147-155). The questions covered all the theorems treated (See Appendix L). The questions are in two parts. The first part required from students to identify the properties and the second part required from them to apply the properties in solving the problem. The post-test contained the same number of items as the pre-test was also administered after the intervention.. The difficulty level of the post-test was similar to the pre-test. However, the items in the post-test were different from those in the pre-test (see Appendix B & C).

According to Creswell (2012), using different test items on pre-test and post-test of a test instrument eliminates biasness from the scores. Pre-test and post-test were administered to all the 101 students selected for the study, in both experimental group The scores of both pre and post-tests were used to answer research questions two and three..

3.5.2 Semi-structured interview

Semi-structured interviews have increased validity because it gives the interviewer the opportunity to probe for a deeper understanding, ask for clarification and allow the interviewee to steer the direction of the interview (McLeod, 2014). The researcher used semi- structured interview to seek both students' and teachers' in-depth knowledge on the causes of poor performance of students in circle theorems. It was administered to 10 randomly selected students: 5 students from the experimental group and other 5 students from the control groups after the post-test (see Appendix D). The mathematics teachers' semi-structured interview guide was developed by the researcher and it was administered to 6 mathematic teachers': 3 mathematics teachers each from experimental and control group's school (see Appendix D & E**).** The interview was used to answer research question 1.

3.6 Reliability

William Trochim (2006), was of the view that reliability is the consistency or dependability of the measurement; or the extent to which an instrument measures the same way each time it is used under the same condition with the same subjects. Moreover, Creswell & Clark (2017) stated that reliability implies scores received from participants should be consistent and stable over time when the instrument is repeatedly administered. Test-retest is one of the ways to conduct reliability test. Test-retest approach was employed by the researcher to examine the reliability of the CTAT in this study. In this present study, researcher conducted piloting the circle theorem achievement test among a different year batch who were not included in the sample of the study and after a month re-administered them to the same students again. The modified and improved instruments were then used in this study. The correlation co-efficient of reliability of CTAT was calculated using Karl Pearson's co-efficient of correlation testing in SPSS of the data collected. The correlation coefficient of reliability of CTAT was 0.92. The reliability coefficients was greater than 0.5, therefore the CTAT was highly reliable and statistically significant coefficient (See appendix J). This could help in achieving research objective for this study.

3.7 Validity

According to Field A. (2013), validity basically means measuring what you think you are measuring. Cohen, Manion and Morrison(2007) asserted that content validity is concern with how an instrument fairly and comprehensively covers the domains or items that it purports to cover as the face validity is where superficially the test appears at face value to test what it is designed to test. To attain content and face validity of the instruments, prepared lesson plans and the test items were checked by a mathematics educator who is a faculty member, and two experienced mathematics WAEC chief examiners in the district to determine whether they were mathematically correct and appropriate for achieving the objectives. According to their comments and recommendations, all lesson plans were revised to obtain a consistency between the objectives and content of the activities. The researcher further gave the instruments to his supervisor to examine after which all remarks, corrections and comments were made.

3.8 Research Procedure

The intervention procedure is divided into three stages, namely, **Pre-Intervention, Intervention and Post intervention**

3.8.1 Pre-intervention stage

The researcher visited the sample selected Senior High Schools and discusses the purpose of the study with the headmasters and Head of Mathematics Departments and also seeks their permission to carry out all exercises of the study that had to do with data collection and intervention (See Appendix M). The researcher after seeking permission to carry out all exercises of the study in the selected sample schools and had the approval, went on and collected his first data on the schedule date by administering pre test to students in both schools on the same day. The researcher collected students work for marking (see Appendix A & G) and analyzed the scores. Four days after the pre-test, researcher met the control and experimental group separately and explain the purpose of the interview to them. The researcher then granted one-on-one interviews to 10 students and 6 mathematics teachers selected from the experimental and control groups. Each interview took a minimum duration of 10 minutes and a maximum duration of 15 minutes.

3.8.2 Intervention stage

Two days after the interview was conducted, the researcher took the experimental group through one week(four class hours) refresher training that emphasized the use of basic tools of GeoGebra in a computer laboratory which was technology equipped. This phase enabled the students familiarize themselves with GeoGebra software usage.During this period, students were taught the usage of the essential tools of the software and making the basic construction in GeoGebra using these tools, such as constructing a regular polygon, construction of circles, point. Students learned some basic functions such as: how to use Geogebra in CAS and GRAPHIC VIEW, how to draw, name and rename a point, how to draw a line segment and lines, how to draw a circle; how to drag the figure; how to delete; how to measure an angle in clockwise and anticlockwise directions, labeling of points etc and how to save one's own work. The refresher training activity was video recorded and the research questions and responses of interviews was audiotaped. After the refresher training the main intervention then took place. Here, students were taking through step by step lesson deliverey in Geogebra lesson environment(See Appendix F).

Lessons were specifically designed practically to meet the criteria of Geogebra learning environments and are included in Appendix F. The researcher facilitated the lesson through demonstrations, individual work, collaborative learning and group work with the expectation that students would work with their group members under the facilitation of the researcher to develop the skills and methods for solving problems related to circle theorem. As the instructor, I closely monitored the process of individuals and groups, and required all participants to give justification for their methods. I carefully designed the lessons to allow students to move from more simple environments for formulation into more complex problems that required usage of a developed method for solving circle theorem problems. As the class progressed into considering more complex theorems, students were expected to draw on previous explorations to find solution to new problems. The lessons were designed to connect the previous knowledge with the current knowledge. The lesson design engages students in developing their own strategies for addressing problems on circle theorem, fitting with basic social constructivist learning principles(See Appendix F), Experimental group lessons were Geogebra usage and had specific objectives for each day to keep the experimental group on pace with the control group. At the end of each lesson, students were given problem set to take home and complete using their newly developed method. These problem sets were short (consisting of two to four problems) and only served to solidify developed understandings.

On the other hand, the control group lessons were taught using the traditional approach described by Stonewater (2005) and Goos (2004) which involved reviewing the homework assignment from the previous day, followed by a presentation of new material, and concluded with a homework assignment. New material was presented using lecture-based instruction that included examples of problems that they would see in their homework, and the formulas required to solve these problems. Parts necessary for substitution into circle theorem formulas were highlighted, and examples included the various theorems. Control group had specific objectives for each day to keep the the same pace with the Experimental group.. At the end of each lesson, students were given problem set to take home and complete using the rules memorized . These problem sets were short (consisting of two to four problems).

Both groups were instructed for a time span of three weeks (ten class hours in total for each group) and taught the same content to reach exactly the same objectives in the cognitive domain with different teaching methods. There were four hours of mathematics lessons in each week, and each lesson hour lasted 60 minutes in both groups. The experimental group students learned circle theorem topics with GeoGebra(See Appendix F), whereas the control group students learned the topics in a Traditional teaching Environment (in a computer-free, non-technologically equipped classroom), which was based on a textbook approach using chapters related to circle geometry from the textbook prepared by the Ministry of Education, Ghana

Education Service for the SHS students. The researcher instructed the experimental group students in the school's computer laboratory with GeoGebra Software Installed on each computer connected to an overhead projector while a different mathematics teacher of the same experience took the control group class. Both of us were teaching the topic based on the lesson's objectives but different approaches. At the end of the three weeks intervention period, both groups of students were given a post-test (See Appendix C).

Below are Fig 3.1 and Fig 3.2 that shows the Classroom environment of the experimental and the Classroom environment of the control group respectively

Fig 3.1 Views from the Experimetal group classroom environment

Fig 3.2 Views from the Control group classroom environment

3.8.3 Post Intervention stage

After the intervention stage the two post test was admimnisteerd to the two groups at the same time. The post-test contained similar items as the pre-test. The post-test also contained a section of problems that required students to identify the circle theorem properties and apply them in finding the missing angles. Such problems required more analysis on the part of the students and a better understanding of the circle theorems relationships that exist among circle geometry. Students' post-test scripts were marked (see Appendix H) and scores analyzed.

Below is the digramatic representation of the research procedure.

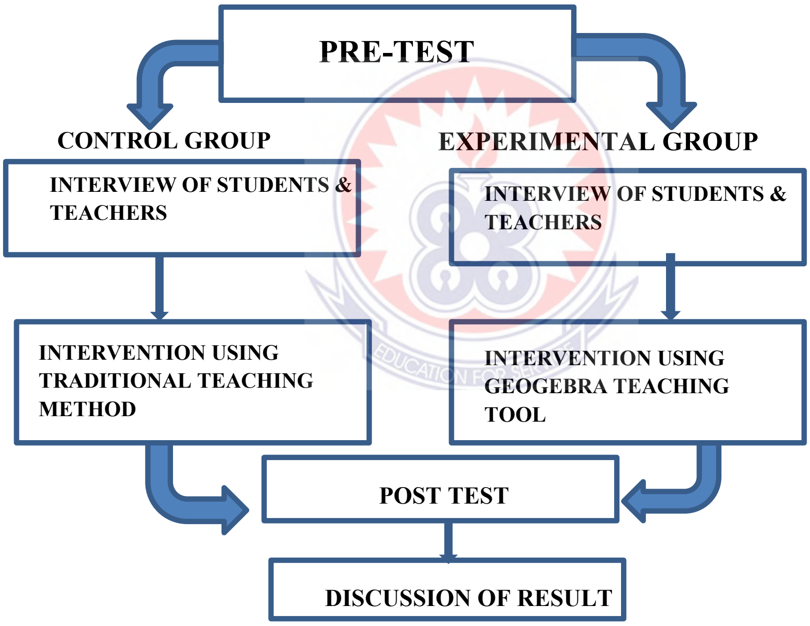

Figure 3.3 diagramatic representation of research procedure.

3.9 Data Analysis Procedure

The first step towards data collection was to hold familiarization meetings with the students and the head of department to brief them on the intention of the study and also make them aware that the data collected would be used only for the purpose of the study (See Appendix M).

The data obtained through the pre-test and post-test and semi-structured interview guide were organized and summarized to obtain sense of information and to reflect on its overall meaning. The data was analyzed quantitatively (descriptive statistics, pair sample t test, independent sample test and effect size) and qualitatively (descriptive words). According to Creswell (2012), descriptive statistics basically helps researchers to summarize the overall trends or tendencies in quantitative data, provides an understanding of the variability of the data and provides understanding of how one score compares with another. Thus, descriptive statistical analysis was used in an attempt to understand, interpret and describe the scores of experimental and control groups from the CTAT. Paired sample t-test and independent samples t-test were run to compare for any significant difference in the mean scores of the experimental and control groups at 95% confidence level which was used to answer research question 2 and 3 quantitatively. The recorded audio from the interviews granted to participants were transcribed and analyzed based on the topical areas contained in the interview guides. The researcher reported all events that emanated from the interviews by describing and interpreting the outcomes after reading the transcribed interview (See Appendix D & E).

3.10 Ethical Consideration

The study participants were kept anonymous. All the participants were treated with respect. The researcher explained the purpose of the study and their rights including withdrawal from participation if they want to do so, without being compelled to give an explanation.

CHAPTER 4

RESULTS AND DISCUSSINGS

4.0 Overview

The main aim of this study is to investigate the effects of GeoGebra teaching tool, on the acquisition of concepts in circle geometry by Senior High School students in Anloga District in Volta Region of Ghana. This chapter has four major sections .The first one is the presentation of demographic information and gender status of participants, followed by the presentation of interview evidence and presentation of of descriptive statistics and independent sample t test tables of pre and post test scores, followed by discussion of results and then lastly analysis of results from the table. The findings include the presentation and analysis/discussion of the result of interview guide and achievement test which is presented in three sections based on the research questions that guided the study using descriptive statistics and independent sample t test related to the Circle theorem Achievement tests and interview.

4.1 Demographic Information of the Participants

The demographic information of students was described in detail in the following two tables. Table 4.1 presents the demographic background of the students according to their gender and Table 4.2 deals with their age group. This was necessary in order to understand the researcher's informants used for the study. A total of 101 final year students of Senior High Schools in Anloga district participated in this study. This was made up of 65 males, representing 64% and 36 females, representing 36%. However, a gender has no effect on the results of this study. This distribution is presented in Table 4.1.

Table 4.1: Gender status of the students

Gender	Control Group	Experimental Group	Total	Percentages
	Traditional Teaching	Dynamic Geogebra software-assisted instruction		
Male	32	33	65	64%
Female	18	18	36	36%
Total	**50**	**51**	**101**	**100%**

Source: Field data, 2021

Table 4.2 shows the age distribution of the students. From Table 4.2, majority 77(76%) of the students were between 17 - 19 years, followed by 18(18%) of them were 20 - 22 years and only 6(6%) of them were between the ages of 14 -16 years. This means that none of them was below 14 years and also above 22 years. Majority of the students are matured enough to give correct responses needed for the study.

Table 4.2: Age Distribution of the Students

Age (years)	Control Group	Experimental Group	Total (%)
14-16	2	4	6 (6%)
17-19	38	39	77 (76%)
20-22	10	8	18 (18%)
Total	**50**	**51**	**101(100%)**

Source: Field data, 2021

4.2 Presentation, Discussion and analysis of Results

The findings have been categorized and presented in three main themes in accordance with the research questions. In answering the hypotheses, the results obtained in the pre-test and post-test were examined and compared for the two groups – experimental and control groups.

To examine the main problem, three research questions were formulated:

1. What are the causes of poor performance of students in circle theorem?

2. What is the impact of traditional method on the academic performance of students in Circle theorem?
3. What is the effect of GeoGebra teaching tool on students' achievement in circle theorems?

4.3 Research Question 1: What are the causes of poor performance of students in circle theorem?

4.3.1 Presentation of results from interviewee responses

Research question 1 sought to find out the causes of poor performance of students in circle theorem. In answering this research question, semi-structured interview was granted to 10 students and 6 mathematics teachers selected from both experimental and control schools. The students' interview data were presented as Interviewer*:*

Do you score high marks in circle theorems exercise?

Interviewee 1*: Hmmm, sir pleases no. I always score low marks. In fact my performance is not good at all in that topic.*

Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 1**: *The way my teacher explains concepts to us by using board illustrations and then follow the explanations up with drills and rote method using examples from textbooks is confusing. It is only the teacher who does everything on the board by himself without engaging us. We see this as teacher-centered, textbook-based teaching approach. This approach looks like lecture method and we only take note and chew or memorize rules without understanding it.*** *The way my teacher taught me; I did not understand it at all. The topic itself is something complex for me.i will never attempt it in my examination.*

Interviewer: How does your mathematics teacher teach circle theorems in your class?

Interviewee 1: ***When the teacher was teaching us this topic, He writes the property or the rules on the board for us to copy and memorize it. Sometimes too, He allows***

us to write the properties or rules one by one as he was dictating. He then solves one example on each property and ask us to solve some from the textbook as class exercise. In fact, he does evryhthing by himself on the board without involving us.I was confused about these properties. I didn't get anything that he taught us sir.

Interviewer: what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 1: *My teacher should use a better method.I suggest my teacher should take his time and teach us well, so that I can also understand it well. Also, He should explain to us how the rules or property come about and how the angles are related.*

Interviewer: Do you score high marks in circle theorems exercise?

Interviewee 2: *No, I always score no or low marks in circle theorem exercise. I even don't answer questions involving circle theorem in end of semester since I may score no or low marks.*

Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 2:I find it difficult to apply more than two rules or properties to solve question. The rules or the properties are confusing to learn and understand and this makes it challenging to me.Only the teacher does everything on the board.only him regulate flow of informationand knowledge in the class. we only memorize rules and solve textbook examples without understanding them.sir am confused. The metod the teacher is using is not good for me at all. I cannot understand anything.

Interviewer: what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 2: I think my teacher should help me to know how to use more than two properties to solve problem.also I want to see how the angles are related in the diagram.

Interviewer: Do you score high marks in circle theorems exercise?

Interviewee 3: *No. I find it difficult to score high marks*

Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 3: the way my teacher teaches the topic is confusing. The teacher writes the rules on the board and ask us to memrise it and pour it back. Sometimes The teacheronly followed the drill and do rote method of memorization.we only children learn through repetition and memorization. I have no idea at all. circle theorems are complicated and difficult so I don't like solving problems on it. I know I will not select questions on the topic even in WASSCE. Thus why I score low marks.

Interviewer: what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 3: I think teachers should help me to change my mind-set that circle theorems are complicated and difficult so I may like to solve more problems on it

Interviewer: Do you score high marks in circle theorems exercise?

Interviewee 4: No, please sir

Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 4: My teacher did not teach me well to understand. He did not know how to go about it. He made it difficult and totally confused me on the topic.

Interviewer: what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 4: I suggest my teacher should have patience with those of us, slow learners to understand the topic since he always moves with the fast learners in class.

Interviewer: Do you score high marks in circle theorems exercise?

Interviewee 5: No Sir, I score very low marks.

Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 5: I have difficulties to transfer knowledge on triangle and parallel lines properties in circle theorems and also I find it difficult to solve problems involving two or more properties.

Interviewer: what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 5: I suggest teachers should teach me triangle and parallel lines properties well then followed by circle theorems so that I can easily transfer knowledge. And also, teachers should help us to solve problems involving two or more properties.

Interviewer: Do you score high marks in circle theorems exercise?

Interviewee 6: No Sir, Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 6: The topic is too difficult for me, I don't understand how the angles are related. It's confusing.

Interviewer: what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 6: My teacher should make it easy for me by teaching it again and show us how the angles are related.

Interviewer: Do you score high marks in circle theorems exercise?

Interviewee 7: No please sir,

Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 7: The way my teacher taught me; I did not understand it. He was moving very fast making everything difficult and confusing. Sometimes, He doesn't draw diagrams.

Interviewer: what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 7: My teacher should take his time to teach it well for me to understand it. I think my teacher should teach it again but draw diagrams and show us how to find missing angles.

Interviewer: Do you score high marks in circle theorems exercise?

Interviewee 8: No Sir,

Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 8: I cannot identify the properties or the rules. Also, I do not practice or solve problems on circle theorems and also the topic is complicated and difficult to me.

Interviewer; what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 8: our teacher should help us on how to identify the properties when the diagrams are drawn. I think I have to practice or solve problems on the topic by allowing friends to teach me and change my mind set that topic is difficult.

Interviewer; Do you score high marks in circle theorems exercise?

Interviewee 9: No sirs please.

Interviewer: what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 9: My teacher made it difficult for me to learn since he just use one period to teach all the nine principles of circle theorems and ask us to use them to solve problems. I did not understand what he taught us.

Interviewer: what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 9: My teacher should re-teach the topic again and this time each theorem with a specific examples and exercises.

Interviewer: Do you score high marks in circle theorems exercise?

Interviewee 10: No Sir

Interviewee: Question; what are the causes of your low (poor) performance in circle theorems exercise?

Interviewee 10: My perception about the topic is that it's difficult. It has many principles that make it more difficult for me to understand and also my teacher made it more difficult for me to understand.

Interviewer: what do you suggest should be done in order to improve on your performance in the topic?

Interviewee 10: My teacher should take his time and find proper way to teach the topic again for me to understand.

The mathematics teachers' interview data were also presented as follows (See Appendix E).

Interviewer: Do your students perform well in circle theorems exercise?

Interviewee 1: No sir please. Almost all my students performed poorly in circle theorem questions.

Interviewer: What are the causes of their poor performance in the topic?

Interviewee 1: Most of my students' have in their mind that it is difficult topic and they are lazy, they don't practice after classroom work. Students have ideal that circle theorems questions are complicated and confusing for that reason they do not pay much attention on the topic

Interviewer: What do you suggest should be done in order to improve on your students' performance in the topic?

Interviewee 1: I think students should change their attitude towards the topic and practice more examples after school.

Interviewer: Do your students perform well in circle theorems exercise?

Interviewee 2: No, their performance is not good in the topic. I think teachers should help to changes students' attitudes on the topic that it is difficult and confusing.

Interviewer: What are the causes of their poor performance in the topic?

Interviewee 2: Students' inability to apply their knowledge on properties of triangle and parallel lines and other properties in solving circle theorem questions. Also, students' cannot apply two or more properties to solve problem.

Interviewer: What do you suggest should be done in order to improve on your students' performance in the topic?

Interviewee 2: I suggest that teachers should create the enabling environment for students to learn well. I also suggest that teachers should help students to apply the *basic principle in plane geometry 1 and how to use more than two circle properties solve a problem*

Interviewer: Do your students perform well in circle theorems exercise?

Interviewee 3: No, their performance in the topic is very bad.

Interviewer: What are the causes of their poor performance in the topic?

Interviewee 3: Students' have problem with connecting one property with others in solving circle theorems problems. And using basic properties of triangles and parallel lines in solving circle theorems problems. Students don't practice or solve problem on the topic. They claim the topic is too difficult for them to learn.

Interviewer: What do you suggest should be done in order to improve on your students' performance in the topic?

Interviewee 3: I think I should form small groups for students' and encourage them to practice more examples on the topic.

Interviewer: Do your students perform well in circle theorem exercise?

Interviewee 4: No sir

Interviewer: What are the causes of their poor performance in the topic?

Interviewee 4: Students are lazy to practices on their own or in group. They are not serious about the topic. They claim it difficult to understand. Students find it difficult to apply the theories to solve problem. Especially problem involving two or more properties and other geometry problem.

Interviewer: What do you suggest should be done in order to improve on your students' performance in the topic?

Interviewee 4: I think they should stop been lazy and be more serious with their studies. Also, *they should change their attitudes towards* the topic that it is difficult.

Interviewer: Do your students perform well in circle theorems exercise?

Interviewee 5: No

Interviewer: What are the causes of their poor performance in the topic?

Interviewee 5: Students have idea that circle theorems questions are complicated and

Confusing for that reason they do not pay much attention on the topic

Interviewer: What do you suggest should be done in order to improve on your students' performance in the topic?

Interviewee 5: I think teachers should help to changes students' attitudes on the topic that it is difficult and confusing.

Interviewer: Do your students perform well in circle theorems exercise?

Interviewee 6: No

Interviewer: What are the causes of their poor performance in the topic?

Interviewee 6: Students find it difficult to apply the theories to solve problem. Especially, problem involving two or more properties and other geometry problem.

Interviewer: What do you suggest should be done in order to improve on your students' performance in the topic?

Interviewee 6: Geometry at the junior high school level should be well strengthened in order to help students comprehend and apply geometry concepts at the senior high school level. Teachers should use more practical ways for students to visualize the properties and discover connections and relations that exist between angles.

4.3.2 Discussion of interviewee responses

Students' have in mind that the topic is too difficult and confusing and for that matter they don't worry themselves to practice examples on it. Teachers don't use the appropriate practical teaching strategies that would create collaborative learning opportunities in the classroom for students to visualize the connections and relationship that exist between the angles.

Students also feel embarrassed when they answer questions wrongly. Also, majority of students said they will not answer any questions on it at the final exam. Almost all the students have made it clear that teachers teaching method (the use of traditional method) in teaching circle theorems has not helped them to understand the concept. This method makes students aware that circle theorem is full of rules that must be chew and pour making it difficult for students to remember apply them without understanding them.

4.3.2.1 Analysis of interviewee responses

Findings revealed that mathematics teachers' classroom attitude does not allow full engagement of students in the classroom activities in their various group work or as individuals. It can be deduced that teachers don't use the teaching method that encourages class participation and active involvement of students. This is consistent with Rukangu (2000) who recommended that the teacher should understand, encourage, motivate and use teaching mehod that allow full engagement of students in the classroom activities in their various group work or as individuals.

It is the common viewpoint of educators that the existing problems related to the teaching cannot be solved by using the traditional teaching methods (Aktümen & Kaçar, 2003). As Usiskin (1982) and Fuys, Geddes and Tischler (1988) promoted, the role of instruction is crucial in teaching and learning geometry. The more systematically structured the instruction, the more helpful it will be for middle school students to overcome their difficulties and to increase their understanding of geometry.

The findings from interviewees' responses from both students' and mathematics teachers' show that poor performance of students is mainly cause by students' ***negative attitude towards circle theorems and the traditional teaching methods employ in teaching the topic.***

4.4 Research Question 2: What is the impact of traditional method on the academic performance of students in circle theorem?

4.4.1 Descriptive statistics and pair sample T test on use of Traditional Method.

Research question 2 sought to find out the impact of traditional method on the academic performance of students in circle theorem. In answering this research question, the researcher gathered and scored all the responses students have given to Pre and Post achievement tests of the control group as tabulated in the Tables 4.3, 4.4

table 4.3 and table 4.4 below reveals the descriptive statistics and pair sample t test respectively of pre and posttest results in the control group (A).

Table 4.3 Descriptive statistics of pre and post-tests of Control group (A)

Tests	N	Minimum	Maximum	Mean	Std. Dev.	Std. Error.
Pretest	50	0.00	19.00	12.10	4.546	0.643
Posttest	50	10.00	29.00	22.26	4.575	0.647

Source: Field work 2021

4.4.1.1 Discussion of Result of pre and post-tests of Control group on use of Traditional Method

Table 4.3 shows comparison of the pre-test and post-test results of the students within the control group. The minimum score students obtained in the pre-test was 0, while the maximum score was 19.00 marks out of 50 Marks. However, in the post-test, the minimum score was 10.00, while the maximum score was 29.00. The mean score of students in the pre-test was 12.10 while that of the post-test was 22.26, an increase of 10.16. This is an indication that in the post-test, every student's performance has slightly increased in the control group.

To ascertain whether the difference between the mean scores was statistically significant, pair samples t-test was performed at 95% confidence level. The result of the pair samples t-test performed on the pre and post-test scores of the control group is presented in table 4.4 below.

Table 4.4 Paired Sample t- test of Pre-test –Post-test scores of Control group (A)

Test	**N 50**	**Mean Difference**	**Std. Deviation**	**Std.Error Mean**	**t-value**	***df***	**Sig**	**cohen**
Pre-test–Post-test		10.16	1.037	0.147	0.922	49	0.00	0.017

Source: Field work 2021.

4.4.1.2 Discussion of Paired Sample t- test of Pre-test –Post-test scores of Control group (A) on use of Traditional Method

A paired samples t-test was examined to compare the pre-test and post test scores for the students taught with traditional teaching approach (control group). The result as presented in Table 4.4 reveals that the mean score difference between the post-test and pre-test of the control group was 10.16 with corresponding standard deviation of 1.037.

The paired sample t-test was examined to find out if the mean score difference ($M = 10.16$, $SD = 1.037$) between the pre-test and pre-test of the control group was statistically significant. This was done to assess the effect of traditional method on students' achievement in circle theorems.

4.4.1.3 Analysis of Pre-test –Post-test scores of Control group (A) on use of Traditional Method

From the discussion of Table 4.4 above, there is an indication that there was statistically significant increase in the students' achievement from the pre-test to the post-test, $t(49) = 0.922$, $p = 0.00 < 0.05$. In addition, **the effect size is approximately**

0.017 which is considered to be a trivial effect (Cohen, 1988). This is an indication that traditional teaching approach also has some minimal effect on students' performance in circle theorems. This effect size value implies that even though there is a significant difference in mean scores, the difference is not really statisitically significant.

From this result, it can be seen that students also gained from traditional teaching approach of learning circle theorems. This outcome is an indication that a well-structured traditional approach of teaching can also improve students' performance in learning circle theorems.

Due to this minimal effect size, the traditional method therefore did not have statistically significant impact on the academic performance of students in circle theorem **among SHS students in Anloa District**. This result is consistent with the common viewpoint of educators that the existing problems related to the teaching cannot be solved by using the traditional teaching methods alone (Aktümen & Kaçar, 2003). This style of traditional teaching method is what Battista (2009) as cited by Marshal (2006) described as ineffective and seriously stunts the growth of students' reasoning and geometric thinking.

4.5 Research Question 3: What is the effect of GeoGebra teaching tool on students' achievement in circle theorems?

4.5.1 Presentation of result of Descriptive statistic, pair sample T test and independent sample t- Test of effect of Geogebra teaching tool on student's achievement in circle theorem.

Research question 3 sought to investigate how the GeoGebra teaching tool helped improved the conceptual understanding and skill development of students after learning with the GeoGebra Software. It is also focused on comparing the effectiveness of GeoGebra on students' acquisition of concepts in circle theorems in the Experimental Group (B) with their counterparts in the control Group (A).

The Circle Theorems Achievement Test (CTAT) was administered to all the 51 students. All the students participated in the study wrote both the pre-test and the post-test of the CTAT. The summary of the scores of CTAT (pre and post) of the students in the Experimental Group is recorded in Table 4.5 .

Table 4.5: Descriptive Statistics of Pre-test Scores of Control and Experimental Groups

Groups	N	Minimum	Maximum	Mean	Std. Dev.
Experimental	51	0.00	18.00	12.00	5.119
Control	50	0 .00	19.00	12.10	4.546

Source: Field Work 2021

4.5.2 Discussion of Pre-test Scores of Control and Experimental Groups

The result from Table 4.7 showed a mean score of 12.00 and standard deviation of 5.119 for the experimental group as compared to a mean score of 12.10 and standard deviation of 4.546 for the control group. The results indicated a mean difference of

0.1 between the mean scores of the two groups with respect to performance in the pre-test.

Also,the pre-test scores of experimental and control groups were compared to determine if there exists any significant difference in the mean scores before treatment. The independent sample T test of the pretest scores of the two groups is presented in Table 4.8 below.

Table 4.6: Independent Samples T-test of Pre-test Scores of Experimental and Control Groups

Independent Sample Test										
		Levene's Test for Equality of Variances		**Test for equality of variance**						
									95% Confidence Interval of the Difference	
		F	**Sig**	**t**	**df**	**Sig(2-tailed)**	**Mean Difference**	**Std.Error Difference**	Lower	Upper
SCORES	Equal variances assumed	1.063	0.305	0.104	99	0.918	0.100	0.964	2.013	1.813
	Equal variances not assumed				98.05	0.917	0.100	0.964	2.011	1.811

4.5.3 Discussion of Independent Samples T-test of Pre-test of Experimental and Control Groups

Table 4.8 represents Levene's test of equality of variance of independent t test conducted for the pre tests score of both control and experimental group. The table indicate F-value of 1.061, Sig. value of 0.305, t-value of 0.104,degree of freedeom value of 99, mean difference of 0.1, standard error of 0.1 and standard error difference of 0.964. At 95% confidence interval, the upper and lower mrans differences are

2.013 and 1.813 respectively. This is conducted to see whether or not there exist any significant differences between the means scores of control and experimental groupg before the start of theintervention.

4.5.3.1 Analysis of Independent Samples T-test of Pre-test of Experimental and Control Groups.

To ascertain whether the difference between the mean scores was statistically significant, independent samples t-test was performed at 95% confidence level. The results of the independence samples t-test performed on both groups is illustrated in Table 4.8 above. The result of leven's test for equality of variances performed on the pre-test scores of the two independent groups: that is experimental and control groups revealed that there was no statistically significant difference between the experimental group and control group. $t(99) = 0.104$, $p = 0.918 > 0.05$. This result indicates that both the experimental and control groups were at the same level in terms of conceptual understanding of the concept of circle theorems before the intervention was carried out.

Table 4.7: Descriptive statistics of pre and post-tests of the experimental group (B)

Tests	N	Minimum	Maximum	Mean	Std. Dev.	Std. Error.
Pretest	51	0.00	18.00	12.00	5.119	0.717
Posttests	51	32 .00	50.00	44.76	5.054	0.708

Source: Field work 2021

4.5.5 Discussion of pre and post-tests of the experimental group

Table 4.9 shows the progress the Experimental group has made after they learned circle theorem using GeoGebra software. The pre and posttest scores of experimental groups was required to determine if there exist any significant difference in the mean scores after treatment.For the Pre test scores table 4.9 shows, minimum value of 0.00, Maximum value of 18.00, Mean value of 12.00, St. Deviation of 5.119, Std. Error Mean of 0.717.

For the Post-test, the minimum value of 32.00, Maximum value of 50.00, Mean value of 44.76, St. Deviation of 5.054 and Std. Error Mean of 0.708 were obtained. This result shows significant improvement of a mean difference of 32.76 representing 73% in the performance of students in the Experimental group B.

Table 4.8: Pair sample t-test of the pre-test and post-test of Experimental Group (B).

Test	N	Mean Difference	Std. Div.	t-value	df	Sig.	Cohen's
Pre-test –Post-test	51	32.765	2.717	3.939	50	0.00	0.78

Source: Field work 2021.

4.5.6 Discussion of the pre-test and post-test of Experimental Group (B).

Table 4.10 is a paired sample t-test which was conducted to compare the pre-test and posttest of the Circle Theorems Achievement Test scores for the students taught with the GeoGebra teaching approach (experimental group) scores at 95% confidence level. This is to find out whether the difference in the pre-test and post-test scores of experimental groups was statistically significant. From Table 4.8, number of participants is 51, meandifference is 32.765, standard deviation is 2.717, t-value is 3.939, degree of freedom is 50, sig. value is 0.00 and cohen, d is 0.78. The results indicated a mean difference of 32.76 which was highly significant.

4.5.6.1 Analysis Pair sample t-test of the pre-test and post-test of Experimental Group (B)

The results of the paired samples t-test (see Table 4.10) of participants from the experimental group who were taught using GeoGebra Software, indicated that there was statistically significant difference in their mean scores of the pre-test and the post-test, $t(50) = 3.939$, $p = 0.000 < 0.05$ and cohen of 0.78.

The effect size the GeoGebra Software impact was calculated to determine the extent of the intervention (see Table 4.10). The effect size Cohen's $d = 0.78$ which indicate a large effect size. This effect size value implies that learning circle Geometry with the use of Geogebra software has made a tremendous improvement in the conceptual understanding and skill development in circle theorem among SHS students in Anloa District.

Table 4.9: Descriptive Statistics of Post-test Scores of Control and Experimental Groups

Groups	N	Minimum	Maximum	Mean	Std. Dev.	Std. Error.
Experimental(B)	51	32.00	50.00	44.76	5.054	1.036
Control(A)	50	10.00	29.00	22.26	4.575	1.001

Source: Field work 2021

4.5.8 Discussion of Post-test Scores of Control and Experimental Groups

Table 4.11 compares the post test scores of the two groups after the experimental group was taught by GeoGebra software and the control group taught by Traditional method. The minimum is 32.00, maximum of 50.00, mean of 44.76 and standard deviation of 5.054 was realized for the experimental group. And the minimum of 10.00 maximum of 290.00, mean of 22.26 and standard deviation of 4.575 was realized for the control group.

The students in the control group have progressed from 0 to 10, an increment of 10 marks out of 50 representing 22% performance whilst the students in Experimental group progressed from 0 to 32 out of 50 marks representing 65% performance.

4.5.8.1 Analysis of Descriptive Statistics of Post-test Scores of Control and Experimental Groups.

From the discussion above, there is an indication that in the post-test, every student's performance has slightly increased in the control group. But the increment in the experimental group was tremendous.

It is obvious that students in the experimental group have outperformed their counterparts in the control group two to three times. This is an indication that the GeoGebra teaching tool has significantly improved the performance of students in the experimental group.

Table 4.10: Independent Samples T-test of Post-test of Experimental and Control Groups

Groups	N	Mean	Std. Div.	t-value	df	Sig.	Cohen
Experimental(B)	51	44.76	5.054	3.985	99	0.000	0.801
Control (A)	50	22.26	4.575				

Source: Field work 2021

4.9.9 Discussion of Independent Samples T-test of Post-test of Experimental and Control Groups

Tabble 4.12 above represents independent sample t test of post test scores of Experimental and Control Groups.

From table 4.12 above, the result of the independent-t test comparing the post-test results of the two groups showed that there was a significant difference between mean performance scores of the control group (N=50, M = 22.26, SD = 4.575) compared to GeoGebra group (N= 51, M= 44.76, SD= 5.054); $t(99) = 3.985$, $p = 0.000 < 0.05$) and effect size of 0.8..

To test the hypothesis that H0: There is no statistical significant difference between the mean scores of the control group and the experimental group in the post-test. Independent samples t-test was conducted at 95%($\alpha \leq 0.05$) confidence level to establish if there was statistically significant difference in the post-test scores between the group taught with (experimental) and their peers in group taught with the traditional method in the control control group.

4.9.10 Analysis of Independent Samples T-test of Post-test of Experimental and Control Groups

From the discussion above, it is clear that the value of cohen equals to 0.80 . This is an indication of a large impact, where (Afana D., Izzo J.C., 2000) indicates that the size of impact is considered large if the value of cohen is greater than or equal to (0.5). This indicates to the existence of significant statistical differences between the mean post scores of the experimental group and their peers in the control group in the achievement posttest; these differences were in favor of the experimental group. This result is consistent with several previous studies, such as the study of Saha et.al.,

2010, Zengin, et.al., (2012), Hkutkemri & Effandi (2012), and Abu ,Ajtaad (2013).

This finding indicated that students who had learned Circle theorem using GeoGebra were significantly better in their achievement compared to students who underwent the traditional learning approach..

The success of Geogebra software to improve the academic achievement of these students may be due to the fact that the capabilities and characteristics of the GeoGebra software, which allows students to see the of abstract geometric concepts and ideas, making it clear and meaningful for them, while the presenting geometric concepts and ideas in the traditional way is often limited to the direct presentation by the teacher, where the student only listens to the teacher's description of the concept, without seeing it, and thus will not be able to visualize (imagine) the concept, and formulate an accurate picture for it, and that means failing to understand the concept well.

Using GeoGebra software converts the classroom to a scientific and cultural entertainment field endeared to the souls, in which the information is delivered to students in an interesting and attractive image; thus, facilitating the understanding process, in which when the students see with his own eyes and hears with his ears, this makes him interact with it by his senses and conscience, making the information firm. The flexible teaching method of the GeoGebra software, which can accommodate a wide range of effective methods and tools and educational activities in an interesting context, where all these elements combine to achieve the desired goals of teaching. GeoGebra software helps increase students' attention; because it provides them with continuous motivati

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.0 Overview

This is the final chapter of the study. The chapter provides the summary of the study and highlights the major findings. It also highlights the conclusions of the study, implications for practice and further outlines some recommendations and directions for future research.

5.1 Summary of Study

The study investigated the effects of dynamic Geogebra software, on the acquisition of concepts in circle geometry by Senior High School Students in Anloga District.

The following research questions guided the study:

1. What are the causes of poor performance of students in circle theorem?
2. What is the impact of traditional method on the academic performance of students in circle theorem?
3. What is the effect of Geogebra teaching tool on students' achievement in circle theorems?

Mixed method design was used as the research design for the study. Semi-structured interview guides and Circle Theorems Achievement Tests (CTAT), were the instruments used in data collection (See Appendices B, C, D, E). The population consisted of all final year senior high school students and mathematics teachers in the Anloga district of the Volta Region. A sample of 101 students and 6 mathematics teachers were selected using simple random and convenience sampling technique respectively. The sample comprised of 50 students in the control group and 51 students in experimental group. The pre-test was conducted before 5 students from each group was selected for interview before the experimental groups were exposed to three weeks treatment with Geogebra teaching tool while the control group was exposed to the traditional approach of teaching for the same period. A post-test, which consisted of similar questions to the pre-test, was administered after the treatment. The results from different data sources were analyzed to answer the research questions that guided the study.

An Independent pair samples t-test and effect size was conducted to investigate the effect of the GeoGebra tool on experimental group students' scores on Circle Theorem Mathematics Achievement Test (CTMAT). The results of the statistical analyses revealed that there was a statistically significant mean difference between the experimental group taught by the Geogebra teaching aid and the control group taught by traditional Instruction with respect to posttest scores of Circle Theorem Mathematics Achievement Test (CTMAT). This result which indicates the positive effect of GeoGebra tool on students' mathematics achievement is consistent with previous research studies in the literature (Bilgici, G. & Selçik, 2011; Filiz, 2009; Zengin, Furkan, & Kutluca, 2012; İçel, 2011:Saha, Ayub, & Tarmizi, 2010).

Several reasons may account for the positive effect of the Geogebra teaching aid on students' achievement. The main reason might be the use of geogebra software which provided students with exciting, interesting and visual way of learning. This learning environment attracted students' attention to the lesson and provided active student participation in the present study as it was also found in the studies of Boyraz (2008) and Choate (1992). Visualization helps students to better understand abstract concepts in a more concrete way (Hacıömeroğlu, 2011). Thus, another possible reason that affected experimental group students' mathematics achievement can be the visualization of the mathematical concepts and ideas which might be provided by dynamic geometry software. To put it differently, the dynamic learning environment might have provided students with a visual way of learning the topic of circle geometry in the present study. The importance of visualization is defined as the main and core component in the teaching and learning of geometry according to the results of previous research studies (Gutiérrez, 1996; Harnisch, 2000). As previously stated dragging is a dynamic movement which allows Geogebra software users to test the hypotheses, observe the regularities and changes and resize the objects (Arzarello et al., 2002). Thus, the features of dynamic geometry software, such as dragging and representations of the concepts both graphically and algebraically, may account for the experimental group students' higher achievement in mathematics than the control group. The results obtained in this study are consistent with the results of previous research concerning the effects of dragging feature of dynamic geometry softwares (Arzarello et al. 2002; Jones, 2000; Healy & Hoyles, 2001;Hölzl, 1996; Sträßer, 2001). This reason can be explained by the comparison of the traditional learning environment with static paper-pencil environment, in which students do not have a chance to observe changes, with the dynamic learning environment, which provides students with a rich learning experience by enabling them to realize the specific properties (i.e. opposite angles of cyclic quadrilaterals add up to 180 degrees) and while students deal with the static drawings with paper-pencil and these drawings present the figure as in the form of its general case in the static learning environment, dynamic learning environment via dynamic geometry software provides students with construction of a figure dynamically which enable them to resize or drag the diagrams to observe the changes and make their own generalizations related to the certain figure. During a construction, when a shape is dragged from its corner, it conserves the properties which are related to it's constrain. Although the size and its position change, the property of the specific diagram remains the same. This kind of characteristic of dynamic geometry environment enables students to comprehend the shape of diagrams with its important properties. It was reported in a study by Hohenwarter et al. (2008) that GeoGebra as a dynamic geometry software helped students to make them better understand the topic with concrete real life examples via visualization in a dynamic learning environment. Furthermore, the students were active participants during the whole class since the lesson prepared required active involvement of students such as making constructions, working on the activities, testing the mathematical ideas and hypotheses. All of these might have been the reason for high mathematics achievement. Moreover, the instant and quick feedback opportunity that students have in a dynamic learning environment may be another reason for the better understanding of the topic and higher achievement since students could instantly see what they did correct or wrong. Also, the instructor's role as a guide rather than a "knowledge transmitter" may be another reason for the experimental group students' higher mathematics achievement in circle geometry. Another possible reason underlying the experimental group students' higher mathematics achievement in transformation geometry can be the immediate calculation and transformation opportunity through visualization and dragging that dynamic geometry software provided. By means of these opportunities, the students did not have to memorize some formulas in order to calculate and transform some variables such as change in position of points at the centre and that of the circumference and angles formed in the same or different segments. For instance, students observed that the angle that a chord or arc subtends at the centre of the circle is twice the angle the arc or chord subtends at the circumference remained the same of the same diagram via visualization and dragging opportunities that DGS provided. In this context, the traditional method in mathematics teaching is criticized since it compels students to memorize mathematical formulas because of its lack of supportive components such as visualization (Fuys, Geddes & Tischler, 1988; Mayberry, 1983). To exemplify, traditional instruction merely involves giving students the rules, such as opposite angles of cyclic quadrilaterals add up to180 degrees. Thus, merely memorizing rules without understanding the idea behind them eventually end up with forgetting or confusing the knowledge obtained. Dynamic geometry software do not only provide understanding of these calculations but also making generalizations. In this study, students resized and dragged the figure drawn using different radii in dynamic environment so that they could immediately observed the changes and make conclusions about existence of certain property. Such a property enabled students to make their own conjectures about the diagrams regarding circle geometry. This may also account for the better understanding of the topic and higher mathematics achievement of the experimental group students, who underwent the DGS-Assisted Instruction using GeoGebra.

The following part focuses on implications for teachers, teacher educators, students, curriculum developers and policy makers based on the findings of this research study.

5.2 Major Findings

The major findings of the study are classified according to the research questions. They are presented under three main sub-headings in accordance with the research questions in this section.

5.2.1 Research Question 1: What are the causes of poor performance of students in circle theorems?

The findings from interviewees' responses from both students' and mathematics teachers' show that poor performance of students is mainly cause by students' attitude towards circle theorems and mathematics teachers' methods or strategies of teaching. Students' have in mind that the topic is too difficult and confusing and for that matter they don't worry themselves to practice examples on it. Moreover, students said they will not answer any questions on it at the final exam. Teachers teaching method (the use of traditional method) in teaching circle theorems was the major cause of students fear in circle theorem. This method makes students aware that circle theorem is full of rules that must be chew and pour making it difficult for students to remember and apply them(See Appendix A). Rukangu (2000) recommended that the teacher should understand, encourage and motivate their pupils.

5.2.2 Research Question 2: What is the impact of traditional method on the academic performance of students in circle theorem?

The result of the pair samples t-test performed on the pre and post -test scores of the control group: that there was statistically significant difference between the means of the pre and post test score. t(50) = 0.001, p = 0.001< 0.05.The effect size is approximately 0.02 which is considered to be a trivial or minimal effect (Cohen, 1988). This effect size value implies that even though there is a significant difference in mean scores, that difference is not really statisitically significant.

The traditional method therefore did not have significant impact on improving the conceptual understanding of students in circle theorem among SHS students in Anloa District. It is the common viewpoint of educators that the existing problems related to the teaching of circle theorem cannot be solved by using the traditional teaching methods alone (Aktümen & Kaçar, 2003). This style of traditional teaching method is what Battista (2009) as cited by Marshal (2006) described as ineffective and seriously stunts the growth of students' reasoning and geometric thinking.

5.2.3 Research Question 3: What is the effect of Geogebra teaching tool on students' achievement in circle theorems?

Findings from the pre-test analysis showed that students in both the experimental and control groups were at the same level in terms of conceptual understanding of the concept of circle theorem before the intervention was carried out. Also, findings from the post-test analysis revealed that students in the experimental group (school B) outperformed their counterparts in the control group (school A) after treatment. The findings also revealed a statistically significant difference in the mean scores between the experimental and control groups in the post-test comparison (See Appendix H).

5.3 Conclusion

Based on the findings from the study, it can be concluded that students' negative attitude and teachers' traditional teaching methods are the main causes of students' poor performance in circle theorems.

It can also be concluded that the Geogebra teaching tool increased students' conceptual understanding in circle theorems and hence increased students' achievement in circle theorems than the traditional instruction. **The findings showed that Geogebra teaching tool as a supplement to traditional classroom instruction is more effective than traditional instruction alone.** The finding of this study is consistent with the study by Hannafin and Foshay (2008), Ahmad Fauzi et. al. (2010)

and Ahmad Tarmizi et. al.(2010) which found positive impact of utilizing mathematical learning softwares thus enhancing students learning and understanding.

In consideration of the immeasurable value of application software, the Geogebra in particular in arousing the interest and improving the academic achievement of learners for a given subject, we can submit that it is high time the software is integrated into our lessons. By its integration in the teaching and learning of mathematics, it has become obvious that complex and difficult concepts that ordinarily would cause students a serious migraine will be overcome by the presence of the Geogebra software application, thus making mathematics an easy subject to learn..

The results of the study indicated that there was a significant difference between the means of the students' scores on the posttest in favor of the GeoGebra group.
It clearly demonstrates the instructional effectiveness of GeoGebra as compared to the traditional construction tools. Traditional teaching approach should supplement the Geogebra teaching approach.

5.4 Recommendations

From the findings of this study, the following recommendations are offered:

- Mathematics teachers should help students to changes their negative attitudes towards circle theorems (that it is difficult and confusing) and other geometry topics in order to sustain their interest in the topic. This can be done through the use of appropriate teaching strategy that actively involves students, arouse their interest and give them the needed environment to ask questions for prompt feedback.

- Mathematics teachers in senior high school level should learn and know how to use the dynamic geometry software Geogebra teaching tool adequately, effectively and systematically since it increases students' conceptual understanding and haven positive impact in their achievement in geometry (circle theorems).
- Mathematics teachers should be provided with opportunities to develop effective teaching methods with the help of technology integration (i.e. lessons conducted on dynamic geometry softwares). They should be provided with in-service education courses on the integration of technology into mathematics teaching to help them gain the necessary competency for teaching with computers.
- Mathematics teachers should be aware of different teaching methodologies, which can be applied in mathematics classrooms, and they should pay special attention to the student-centered and technology enriched instruction methods. These methods can be easily applied and do not require much time and money and they provide conceptual understanding of concepts in mathematics. This software provide teachers and students with a free new tool, a new way of using technology with visual aids to help students to interact with the mathematical concepts individually or in groups, in the classroom, or at home, or at the most convenient place according to needs of the teachers and students using computers.
- This tool can be use by teachers as complementary activities to the regular classroom setting, where students can get immediate feedback of their findings, in the classrooms activities as well as in their homework.

- Providing teachers during-service with all the knowledge and skills related to technological innovations, especially Geogebra software and its use in the educational process.
- The need to train mathematics teachers during-service, through courses, workshops, and other teaching methods, on the use of Geogebra software in the teaching and learning of mathematics in the various stages of education, to positively raise the academic achievement and for the development of visual thinking skills.
- Including courses on methods of teaching mathematics, topics that discusses the use of Geogebra software in the teaching of mathematics, as well as different methods of how to train students on the development of visual thinking skills in teacher preparation institutions.
- As for teacher educators, faculties of education should include various courses to train prospective teachers for adequate and effective use of technological tools in mathematics teaching since such skills were needed and used as the main part of the instruction given to the students by the researcher.
- Curriculum developers should also consider the effectiveness of DGS-Assisted Instruction on the development of geometric reasoning and take into account the results of the present study during the curriculum development process. Moreover, the integration of dynamic mathematics softwares into mathematics curriculum and its importance should be highly emphasized rather than merely remaining as a recommendation as in the Teacher Guide Textbook, which says "Dynamic Geometry Software may be utilized". For instance, curriculum developers may insert dynamic mathematics-based activities or tasks in the textbook as applications of the topics in a dynamic learning environment.

Also, the teachers should be provided with extra time for the use of dynamic mathematics softwares in the teaching of the topics covered in the secondary school mathematics curriculum. In other words, the activities based on dynamic mathematics software should be included in the mathematics textbooks for the secodary students.

- The necessity by Government of activating the schools for the learning resource centers, and providing them with the tools, methods, and techniques of modern education, and with a sufficient number of computers to commensurate with the number of students, and downloading some educational programs for teaching mathematics on those devices to take advantage of them.

Teachers should also take into account that achievement in geometry and geometric thinking are moderately strongly correlated (Usiskin, 1982), as it was found in the present study and the fact that the use of dynamic geometry software affects students' geometric thinking significantly. Due to this positive correlation, teachers should be aware of the importance of geometric thinking and the fact that it can be increased over time if appropriate materials and teaching methods are used. Considering all the advantages dynamic geometry software provided and the correlation between mathematics achievement and geometric thinking, the mathematics teachers are recommended to use such softwares in their mathematics lessons while they are teaching different subjects through longer time span to provide better understanding and permanent learning and to get better results in mathematics teaching.

Above all, the intention behind using GeoGebra in the teaching-learning of mathematics should not be to replace the traditional approach; rather, to supplement it.

5.5 Suggestions for Future Research

The findings of this study bring to bear a lot of related educational implications.

These implications of the findings of this study calls for further research in Geogebra teaching approach in teaching and learning of mathematics in Ghana. The following areas are suggested for further research:

- Study in this area can be done to investigate other areas of geometry such as plane geometry I, mensuration I and II as well as other concepts in SHS thematic syllabus to obtain a general picture of the effects of geogebra teaching tool on students' achievement
- . In order to gain evidence related to the long-term effects of Geogebra teaching tool on students' mathematics achievement in circle geometry and attitude towards mathematic, further research studies could be conducted through a longer time span of treatment.
- Further research studies may be conducted with students chosen randomly from private secondary schools. In this way, the researchers may also have a chance to increase the generalizability of their study results to a broader population which has similar characteristics to the sample of their study.
- The effect of this instruction method can be investigated on the effect of using GeoGebra on the performance of students in mathematics this could be extended to variables like gender, school locations, organization and school types.

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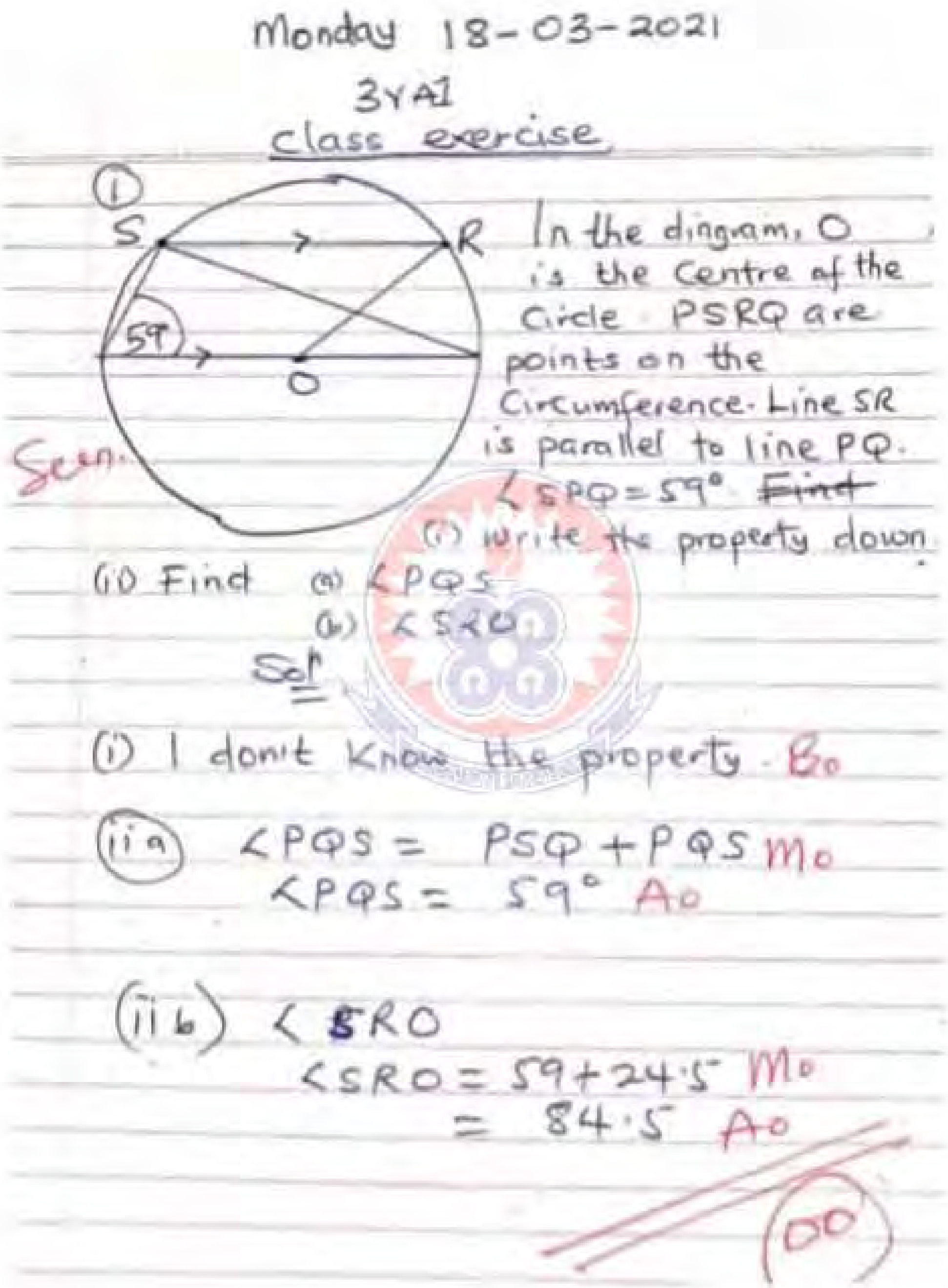
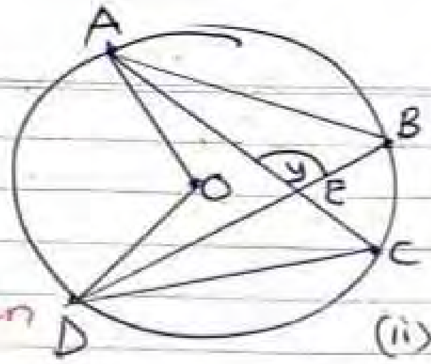
APPENDIX A

Evidence of Students' Difficulties in Solving Circle Theorems Problems.



(2)



In the diagram O is the Centre
(i). Which property can you identify?
(ii) Find angle y.

Seen

Soln

(i) No property is there. B0

(ii) AOD = 100
AEB = y Seen
BDC = 40

AEB = y = 100 + 40 = 180 − 140
= 140 = 180 − 140°
= 180 − 140
= 40° A0

M0

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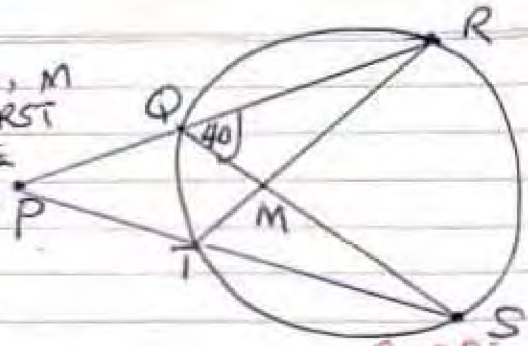
(3)

In the diagram, M is the Centre. QRST are points on the Circumference



Find

(i) ∠SMR

(ii) ∠RTS

Seen

Sol$^{\underline{n}}$

∠SMR

∠SMR = 180 − 40 Mo

= 140° Ao

(ii) ∠RTS

140 + 180 − 40 = 360 Mo

= 280

∠RTS = 280° Ao

00

00/12

APPENDIX B

Pre Test of Circle Theorems Achievement Test (ctat)

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO.

While you are waiting, read carefully the following instructions.

INSTRUCTIONS

1. Write your name, class and the name of your school in the spaces provided below.

2. Answer all questions. [50 marks in all]

3. You must show working by writing your solutions to every question in the spaces provided.

4. You have 60 minutes to complete the test.

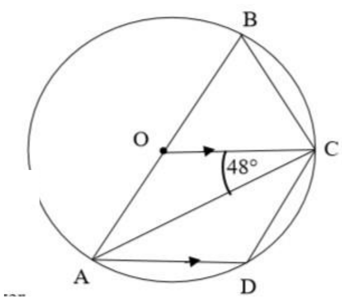
NAME: ....

CLASS:..

SCHOOL: ....

Answer all questions. You must show working in all. [50 marks in all]

1. In the diagram, O is the centre of the circle, $|OC|$ is parallel to $|AD|$, $|AB|$ is a straight line and angle OCA = 48°.
 (A) Identify the property (ies).
(B) Calculate the value of the angle ABC [4 marks]



Answer..
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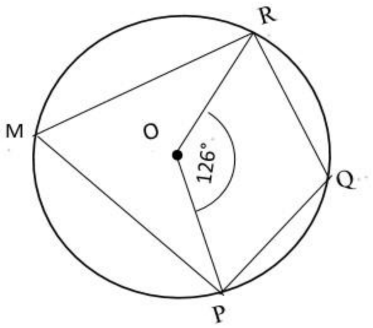
2. In the diagram below, O is the centre of the circle and angle POQ = 126°.

(A) Identify the property (ies).

(B). Find angle PQR. [4 marks]



Answer...

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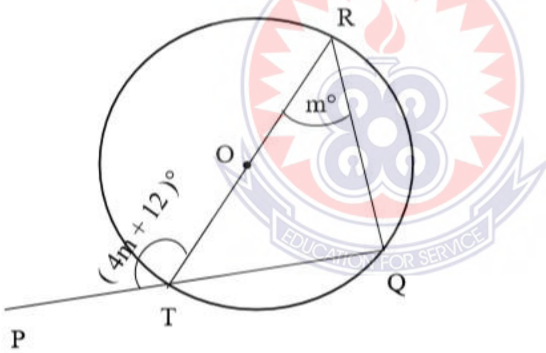

In diagram, TR is the diameter, angle TRQ = a ° and angle PTR = (4a +12) °.

(A) Identify the property (ies).

(B) Calculate the value of a. [4 marks].

Answer...

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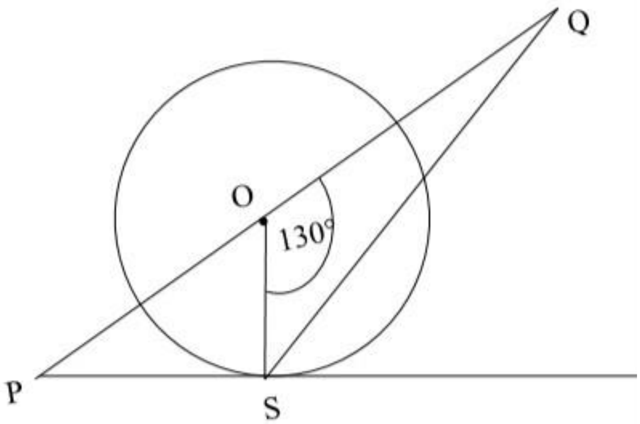

4.
In the diagram, O is the centre of the circle. $\overline{PR}$ is a tangent and angle SOQ = 130°.
(A) Identify the property (ies)
(B) Calculate the size of angle OPS. [6 marks]
Answer...
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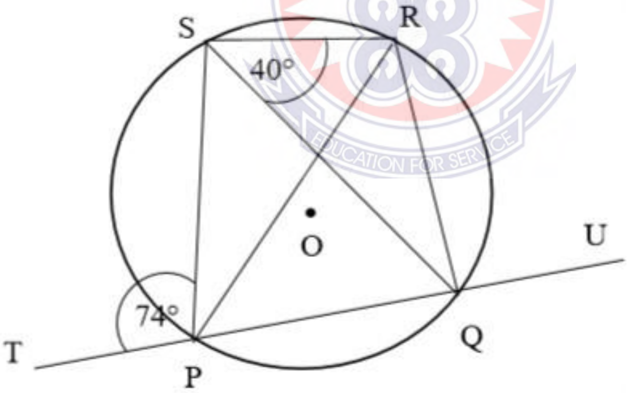
5.



The diagram above, O is the centre of the circle, angle TPS = 74° and angle QSR = 40°.
(A) Identify the property (ies).
(B) Calculate the value of angle SQR. [4 marks].
Answer...
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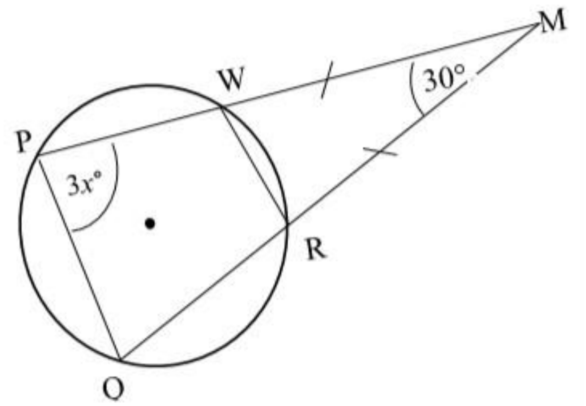
6.



In the diagram above, line PW and QR are produced to meet at M, where angle WMR = 30° and |WM| = |MR|.

(A) Identify the property (ies).

(B) Find the value of x. [6 marks].

Answer...
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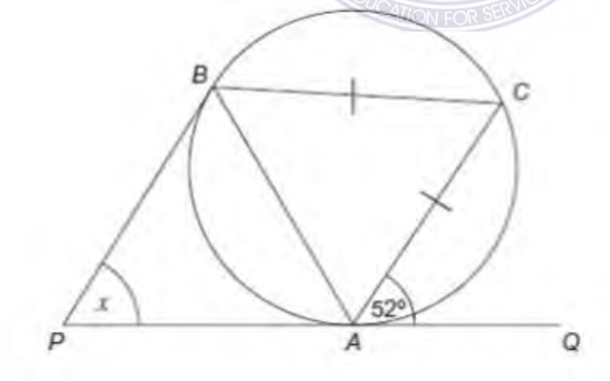
7. PAQ and PB are tangents on the circle such that AC = BC.



(A) Identify the property (ies).

(B) Solve out for the size of angle x. [6 marks]

Answer...
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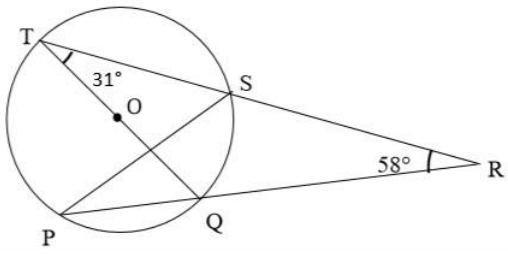
8.



(A) Identify the property (ies).

(B) Find the value of angle TSP in the diagram. [6 marks]

Answer...

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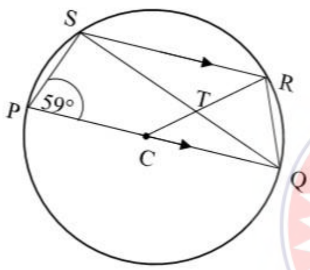
9.



In the diagram above, C is the centre of the circle, STQ and PCQ are straight lines and SR is parallel to PQ, angle SPQ = 59°.

(A) Identify the property (ies).

(B) Find angle RCQ. [6 marks]

Answer...

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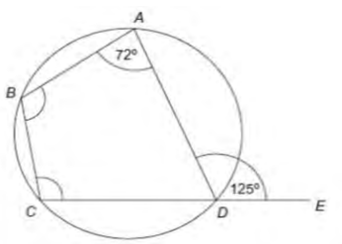
10. Points A, B, C, and D are on the circumference of the circle. CDE is a straight line



(A) Identify the property (ies) and calculate the size of angle BCD and give reason for your answer. [2 marks]

(B) Work out the size of angle ABC [2 marks]

Answer...

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APPENDIX C

Post-Test of Circle Theorem Achievement Test (CTAT)

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO.

While you are waiting, read carefully the following instructions.

INSTRUCTIONS

1. Write your name, class and the name of your school in the spaces provided below.
2. Answer all questions. [50 marks in all]
3. You must show working by writing your solutions to every question in the spaces provided.
4. You have **60 minutes** to complete the test.

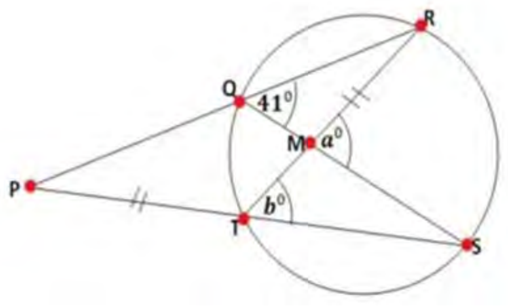
NAME: ....

CLASS: ....

SCHOOL..

Answer all questions. You must show thorough working in all. [50Marks]

1.



In the diagram below, M is the centre.$\angle RQS = 41^0$.
(A) Identify the property (ies), and write them down
(B) find $\angle RMS$ and $\angle RTS$.[**4MARKS**].

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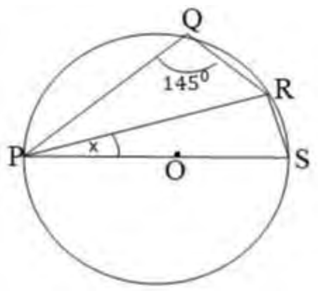

The above diagram has $\overline{PS}$as the diameter with O as the centre. PQRS are points on thr circumference. $\angle PQR = 145^0$.

(A) Identify the property (ies), and write them down

(B) find ∠ PSR and ∠RPS. [**4MARKS**].

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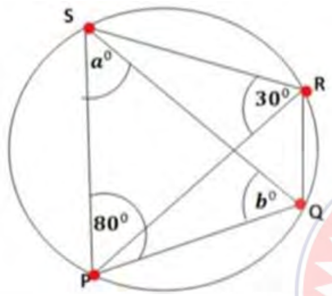

The diagram, is a cyclic quadrilateral with $\angle SRP = 30^0$, $\angle SPQ = 80^0$.

(A). Identify the property (ies), and write them down

(B). find the ∠QSP and ∠SQP.[**4MARKS**].

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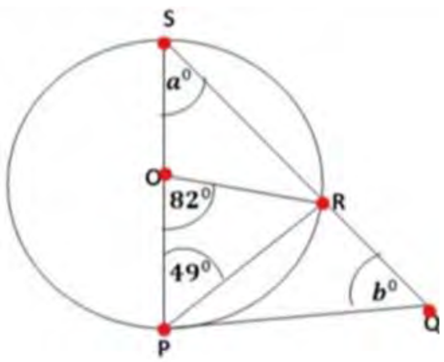

In the diagram, SP is a diameter with centre O. if $\angle ROP = 82^0$,$\angle OPR = 49.^0$

(A) Identify the property (ies), and write them down

(B) find ∠RSQ and ∠RQP.[**4MARKS**].

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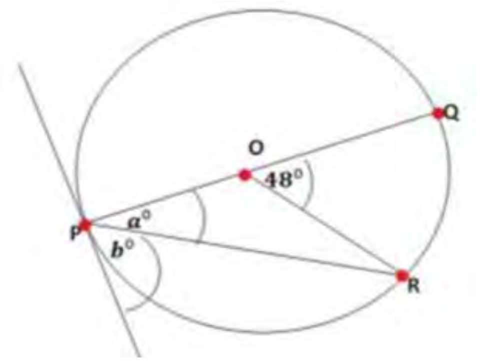

In the diagram, QPR is circle with centre O. $\angle QOR = 48^0$, $\overline{SP}$ is a tangent.

(A) Identify the property(ies), and write them down .

(B) find the values of a and b.[**4MARKS**].

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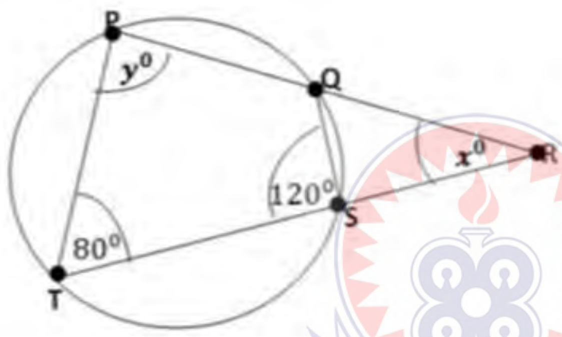

In the diagram $PTSQ$ is a circle. $\angle PTS = 80^0$, $\angle TSQ = 120^0$.
(A) Identify the property (ies), and write them down
(B) find $\angle QPT$ and $\angle SRQ$.[**6MARKS]**

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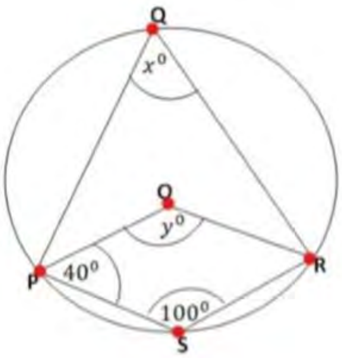

In the diagram, $PQRS$ is a circle with centre O. $\angle QPS = 40^0$, $\angle PSR = 100^0$.

(A) Identify the property (ies), and write them down
(B) find $\angle PQR$ and $\angle POR$. [**6MARKS**].

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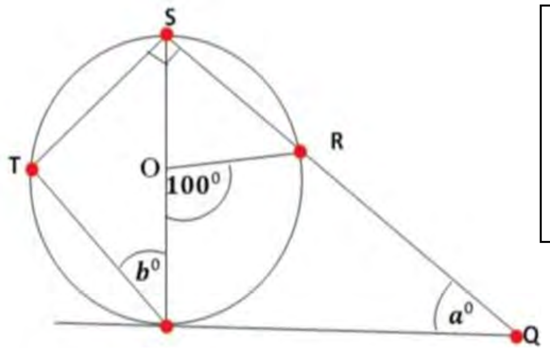

In this diagram, $PRST$ is a circle with centre O. $\angle ROP = 100^0$, I

(A) Identify the property (ies), and write them down

(B) find $\angle PQR$ and $\angle$SPT **[6 MARKS]**

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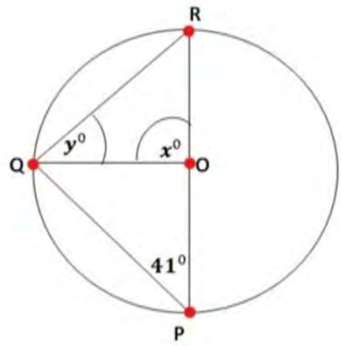
9.



In the diagram, PQR is a circle with centre O and a diameter PR. $\angle QPO = 41^0$.

(A) Identify the property (ies), and write them down

(B) find $\angle RQO$ and $\angle$ROQ . **[6MARKS]**

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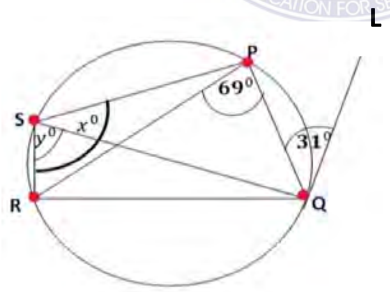
10.



In the diagram, PQR is a cyclic quadrilateral $\overline{LQ}$ is a tangent . $\angle LQP = 31^0$, $\angle QPR = 69^0$.

(A). Identify the property (ies), and write them down

(B). find $\angle QSR$ and $\angle$PSR .**[6MARKS]**

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APPENDIX D

Students' Semi-Structured Interview Guide

Interviewee code: ______________________

Hello, my name is Kafui kugblenu, an MPhil, Student from the University of Education, Winneba. The purpose of this interview is to find out from you the main causes of your good or poor performance in circle theorems exercise. There are no right or wrong answers. I would like you to feel comfortable and say what you really think and how you really feel about the questions I will be asking you. I will be recording our conversation so that I can get all the details. I assure you that all your responses and comments will remain confidential.

Warm up: Briefly tell me about yourself.

1. Do you score high mark in circle theorem exercise? Yes / No If yes,

2. What are the causes of your high performance in circle theorems exercise?

....

....

If no, what are the causes of your low (poor) performance in circle theorems exercise?

....

....

3. What do you suggest should be done in order to improve on your performance in circle theorems exercise?

....

....

Thank you for your time.

APPENDIX E

Mathematics Teachers' Semi-Structure interview Guide

Interviewee code: _____________________

Hello Sir/Madam, my name is Kafui Kugblenu, an MPhil, Student from the University of Education, Winneba. The purpose of this interview is to find out from you the main causes of students' poor performance in circle theorem. There are no rights or wrong answers. I would like you to feel comfortable and say what you really think and how you really feel about the questions I will be asking you. I will be recording our conversation so that I can get all the details. I assure you that all your responses and comments will remain confidential.

Warm up: Briefly tell me about yourself.

1. Do your students perform well in circle theorems exercise? Yes / No If yes,
2. If yes, What are the causes of their good performance in circle theorems exercise?

   ....

   ....

   If no, what are the causes of their poor performance in circle theorems exercise?

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3. What do you suggest should be done in order to improve your students' performance in circle theorems exercise?

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Thank you for you very much for your time.

APPENDIX F

Lesson Plan of Experimental group

LESSON PLAN ONE

Subject: Core Mathematics

Topic: Circle Theorems

Sub-area of Learning: Circle theorem 1

Target group: 12^{th} grade level (14-22years old).

Duration: 120 minutes (two class hours)

Class: 3E1 -A

Teacher: Kafui Kugblenu

Prerequisites Knowledge (Relevant Previous Knowledge):

Students can use GeoGebra teaching tool to draw shapes and measure angles between two lines joined together and are also familiar with basic concepts about circle such as radius, centre, arc, segment, and circumference and can easily tell the properties of isosceles triangle, angles on a straight line, quadrilateral such as trapezium, parallelogram, kite, and rhombus.

Required Materials/Resources:

Computer with GeoGebra software classic 5.0 installed for each student, Beamer/projector, projection screen (or cotton sheet) etc., pencil, jotter, activity sheet, worksheet.

Learning Objective(s):

By the end of the lesson, the student will be able to:

1. Identify Angles that have common chord or common arc.
2. Identify the relationship between central angle of a circle and its inscribe angle standing on the same arc or chord.
3. Write down the relationship between central angle of a circle and its inscribe angle standing on the same arc or chord.
4. Use the relationship to solve simple problems involving central angle of a circle formed at the centre and its inscribe angle standing on the same arc or chord at the circumference.

Skills: Computer usage, Geogebra Exploration, Geometrical Thinking, Mathematical Reasoning, Mathematical Correlation.

Teaching and Learning Activities (Description of the procedures):

Introduction (8minutes)

Researcher review students' previous knowledge on exploration of interface of Geogebra.

Main lesson

Students are introduced to the topic of today by the researcher. And Students' previous knowledge on some basic concepts of circle and some basic properties of isosceles triangle, angles on a straight line, quadrilateral such as trapezium, parallelogram, kite, rhombus are freshened by the researcher.

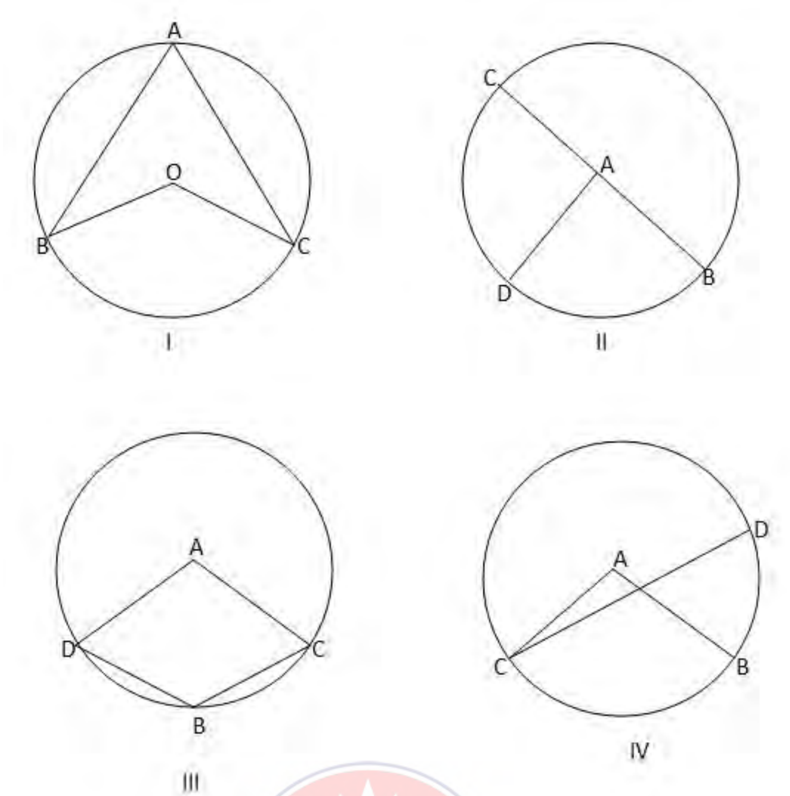
The researcher brainstorms students on how the Geogebra is used to draw circle and line segments are drawn with a given radii and how angles formed between lines are measured.

Researcher guides students to open the Geogebra software in CAS or Graphic view and use it to draw three or four circles of different sizes (radii) with centre O.

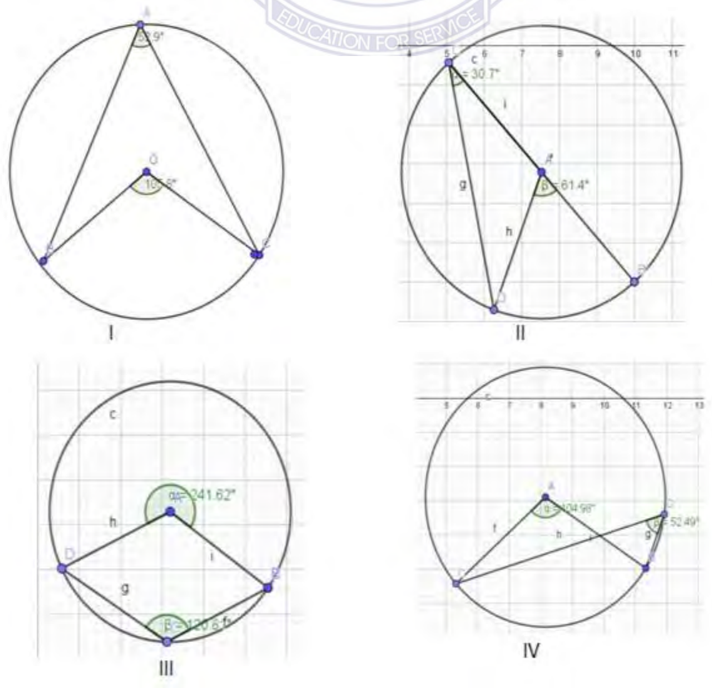
Researcher guides students to identify three other points on the circumference and label them as points A, B, C.

Researcher guides students to join all these points with a straight including the centre.

Researcher guides students to identify the central angle and the inscribe angle and guide them to identify common chord or the common arc between the central angle at the centre and the inscribe angle at the circumference.



The researcher guides students to select the appropriate tool to measure angle < BAC and a central angle < BOC standing on same arc in graphical view of GeoGebra.



The researcher asks students to record the angles between the central angle and the angle formed at the circumference in all the figures drawn on their record sheet as done below.

FIGURE	CENTRAL	INSCRIBE	RESULT
I	<BOC=105.8	<BAC=52.9	<BOC=2<BAC
II	<DAB=61.4	DCB=30.7	<DAB=2<DCB
III	<DAB=241.62	<DCB=120.81	<DAB=2<DCB
IV	CAB=104.98	<CDB=52.49	<CAB=2<CDB

The researchers ask students to interact with their colleagues and observe the relationship that exist between the central angle and angle formed at the circumference by the same arc.

After the interaction, the Researcher used PowerPoint to fill his table.

Researcher should ask students what conclusion was derived from their observation and interactions. Students should give answer as here; the central angle BOC at the centre is double of the inscribed angle BAC at circumference standing on the same arc BC. Thus, the central angle of circle is double of the inscribed angle standing on the same arc was conclusion for figure one.

After that researcher and students both interact each other about figure as well as statement of the theorem together. In which researcher first give priority to students for their answers and teacher nextly discuss students' answer and lastly demonstrates and ‘Given’, ‘To prove', 'Statements' and 'Reasons' in PowerPoint. In same time students write answer by watching slides. Hence the first theorem

The Researcher guides students to solve several examples using the statement of the property in groups. The researcher should allow students to interact with friends to share ideas on their solutions. Researcher allows students in groups to practice series of questions. The researcher finally gives quick feed back to students and address individual difficulty in the class.

Conclusion

Two questions were given to students as take home assignment.

APPENDIX G

Sample of Marked Pre-Test

16/50

1st Jul, 2021

APPENDIX B: Pre-Test of Circle Theorem Achievement Test (CTAT)

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO.

While you are waiting, read carefully the following instructions.

INSTRUCTIONS

1. Write your name, class and the name of your school in the spaces provided below.
2. Answer all questions. [50 marks in all]
3. You must show working by writing your solutions to every question in the spaces provided.
4. You have **60 minutes** to complete the test.

NAME: 31B

CLASS: VA3A

SCHOOL B

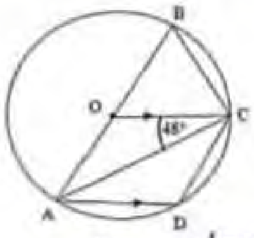
01-07-2021

Answer all questions. You must show working in all. [50 marks in all]

1. In the diagram, O is the centre of the circle, $|OC|$ is parallel to $|AD|$, $|AB|$ is a straight line and angle OCA = 48°.

(A). Identify the property (ies).

(B)Calculate the value of the angle ABC [4 marks]



Answer A. please I don't know ×

B. ∠ABC = 180 − 2(48) = 84 M0 M0 M1

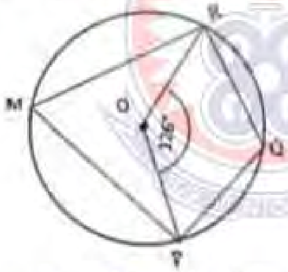
∠ABC = 180 or 84° A0

01

2. In the diagram below, O is the centre of the circle and angle POQ = 126°.

(A). Identify the property (ies).

(B). Find angle PQR. [4 marks]



Answer A. Angle at the point are equal. ×

∠POR = 360 − 126 = 234 M1

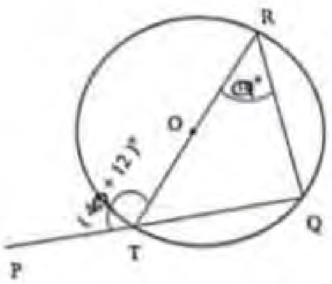
∠PMR = ½(126) = 63 M1

∠PQR = 126 + 63 = 189° M0 A0

02

Page 2 of 6

3.



In diagram, TR is the diameter, angle TRQ = a ° and angle PTR = (4a +12) °.

(A). Identify the property (ies).

(B).Calculate the value of a. [4 marks].

Answer A. Angle at diameter and cente. X

B. $4a+12 = a°$ MoMo

$3a=12$, $a=3°$ Mo Ao

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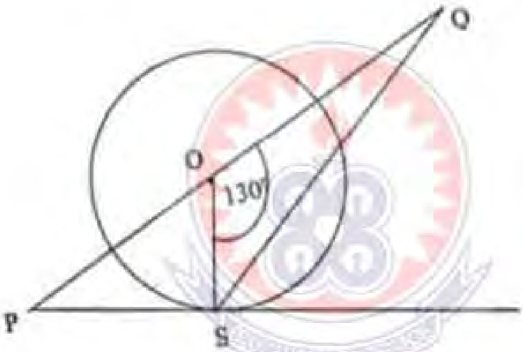
4.



In the diagram, O is the centre of the circle. $\overline{PR}$ is a tangent and angle SOQ = 130°.

(A) Identify the property (ies)

(B) Calculate the size of angle OPS. [6 marks]

Answer A: the property of equilateral. ×

$\angle OPS = 130+180$ MDMDMD

$OPS = 180°+130 = 310°$ MDMDA0

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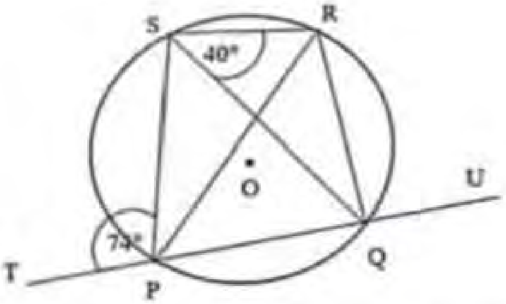
5.



The diagram above, O is the centre of the circle, angle TPS = 74° and angle QSR = 40°.

(A) Identify the property (ies).

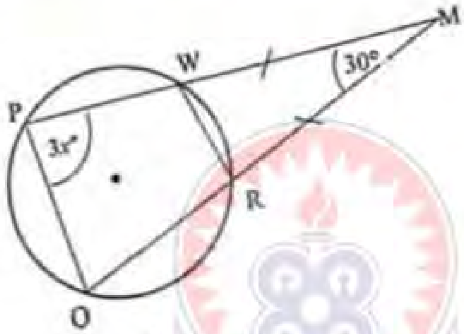
(B) Calculate the value of angle SQR. [4 marks]

Answer: A. Cyclic quadrilateral-opposite angles are equal.

∠SQR = RPS = 40° M1 M0 M0 A0

01

6.



In the diagram above, line PW and QR are produced to meet at M, where angle WMR = 30° and |WM| = |MR|.

(A) Identify the property (ies).

(B) Find the value of x. [6 marks].

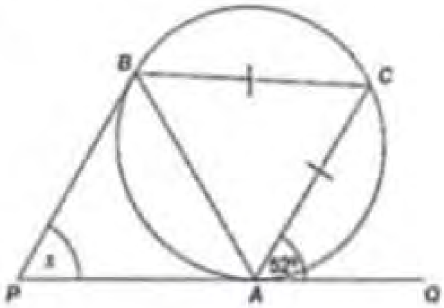
Answer: A. Cyclic quadrilateral and External angle are equal. Base angle of Isoceles △ are equal.

2(3x) + 30 = 180 ⟺ 6x = 150 ⟺ x = 25 M1 M1 A1

∠PQM = MPQ = 3x M1 seen.

06

7. PAQ and PB are tangents on the circle such that AC = BC.



(A) Identify the property (ies).

(B) Solve out for the size of angle x. [6 marks]

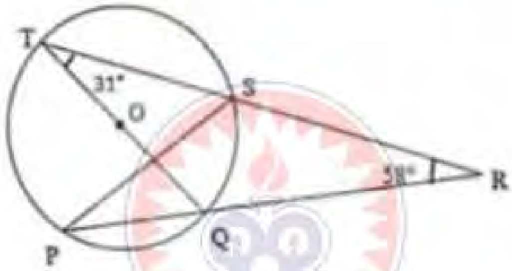
Answer A. can't remember ×

x + 52 = 180 M0 M0 M0

x = 180 − 52 = 128° M0 M0 A0

00

8.



(A) Identify the property (ies).

(B) Find the value of angle TSP in the diagram. [6 marks]

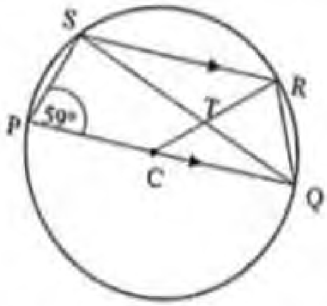
Answer A. Angle at the centre. ×

<TSP = PQT M1

< STQ = SPQ M1 M0 M0 M0 A0

02

9.



In the diagram above, C is the centre of the circle, STQ and PCQ are straight lines and SR is parallel to PQ, angle SPQ = 59°.

(A) Identify the property (ies).

(B) Find angle RCQ. [6 marks]

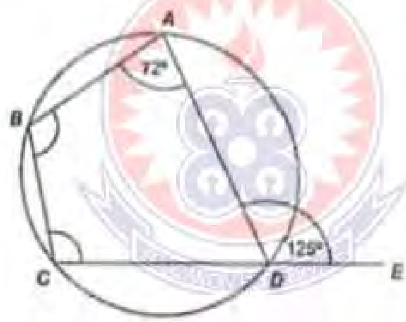
Answer A. opposite angles are equal. Cyclic quadrilateral.

B. ∠RCQ = 59+180 = 239° M0 M0 M0

∠RCQ = 239° M0 M0 A0

00

10. Points A, B, C, and D are on the circumference of the circle. CDE is a straight line



(A) Identify the property (ies) and calculate the size of angle BCD and give reason for your answer. [2 marks]

(B) Work out the size of angle ABC [4 marks]

Answer A: Cyclic quadrilateral

∠CDA = 180 − 125 = 55° M1 M1

∠ABC = 180 − 55° M1 125° A1

04

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APPENDIX H

Sample of Marked Post-Test Scripts

49/50

APPENDIX C: Post-Test of Circle Theorem Achievement Test (CTAT)

28th July 2021

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO.

While you are waiting, read carefully the following instructions.

INSTRUCTIONS

1. Write your name, class and the name of your school in the spaces provided below.
2. Answer all questions. [50 marks in all]
3. You must show working by writing your solutions to every question in the spaces provided.
4. You have **60 minutes** to complete the test.

NAME: 3B

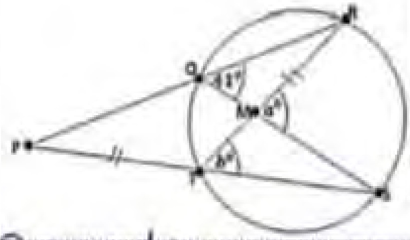
CLASS: VA3A

SCHOOL: B

28-07-2021

Answer all questions. You must show thorough working in all. [50marks]

1.



In the diagram below, M is the centre $\angle RQS = 41^{\circ}$.

(A). Identify the property (ies), and write them down

(B). find $\angle RMS$ and $\angle RTS$.**[4MARKS]**.

Properties = property 1 and Property 2

$2\angle SQR = \angle SMR$ M1

$2(41) = a^{\circ}$

$82^{\circ} = a$ A1

$\angle STR = \angle RQS$ M1

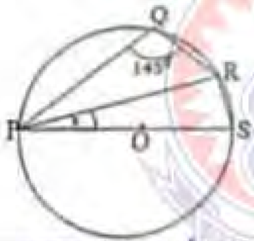
if $= b$

$\angle STR = 41^{\circ}$ A1

04

seen

2.



The above diagram has $\overline{PS}$ as the diameter with O as the centre. PQRS are points on thr circumference. $\angle PQR = 145^{\circ}$.

(A). Identify the property (ies), and write them down

(B). find $\angle$ PSR and $\angle$RPS. **[4MARKS]**.

properties = 3 and 4

$\angle PSR + \angle PQR = 180^{\circ}$ M1

$\angle PSR = 180 - 145$

$\angle PSR = 90^{\circ}$ A1

$\angle RPS = 180 - (90^{\circ} + 35^{\circ})$

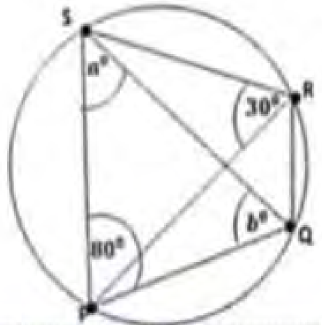
$\angle RPS = 180 - 125^{\circ}$ M1

$\angle RPS = 55^{\circ}$ A1

04

seen

3



The diagram, is a cyclic quadrilateral with $\angle SRP = 30^0$, $\angle SPQ = 80^0$.

(A). Identify the property (ies), and write them down
(B). find the $\angle QSP$ and $\angle SQP$. **[4MARKS]**.

properties = property 2 and Property 10 ✓

$\angle SRP = \angle PQS$ M1

$b^\circ = 30^\circ$ A1

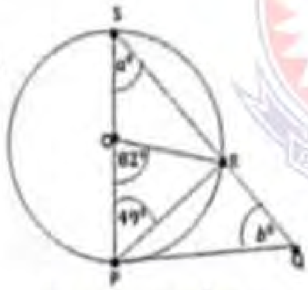
$\angle QSP + \angle SPQ + \angle PQS = 180$ M1

$a^\circ = 180 - 30 - 80$

$a^\circ = 70^\circ$ A1

04

4.



In the diagram, SP is a diameter with centre O. if $\angle ROP = 82^0$, $\angle OPR = 49^0$

(A). Identify the property (ies), and write them down
(B). find $\angle RSQ$ and $\angle RQP$. **[4MARKS]**.

properties = property 1 and Property 3 ✓

$2\angle PSR = \angle PTR$ M1

$2a = 82$

$a = 41^\circ$ A1

$\angle QSP + \angle SPQ + \angle PQS = 180^\circ$

$\angle PQS = 180 - 131$ M1

$\angle PQS = 49^\circ$ A1

04

Page 3 of 6

5. 

In the diagram, QPR is circle with centre O. $\angle QOR = 48^0$, $\overline{SP}$ is a tangent.

(A) Identify the property(ies), and write them down .

(B). find the values of a and b.**[4MARKS]**.

Properties = property Six and Property eight ✓

$2a + 180 - 48° = 180$ M1

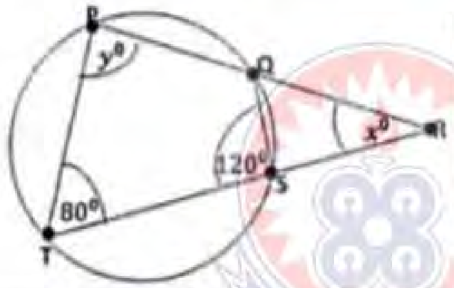
$2a = 48$

$a = 24°$ A1

$b° = 90° - 24°$ M1

$b° = 66°$ A1

(04)

6. 

In the diagram *PTSQ* is a circle. $\angle PTS = 80^0$, $\angle TSQ = 120^0$.

(A). Identify the property (ies), and write them down

(B). find $\angle QPT$ and $\angle SRQ$.**[6MARKS]**

properties = property four and Property five ✓

$\angle TPS + \angle TSQ = 180$ M1

$y° = 180 - 120°$ M1

$y° = 60°$ A1

$\angle RPT + \angle PTR + \angle TRP = 180°$ M1

$60 + 80° + x = 180°$

$x = 180 - 140$ M1

$x = 40°$ A1

(06)

Page 4 of 6

7.

In the diagram, *PQRS* is a circle with centre O. ∠*QPS* = 40°, ∠*PSR* = 100°.

(A). Identify the property (ies), and write them down
(B). find ∠*PQR* and ∠POR . **[6MARKS]**.

Properties= property One and propoty Nine ✓

∠PSR + ∠PQR = 180 M1

100 + x = 180 M1

x = 80° A1

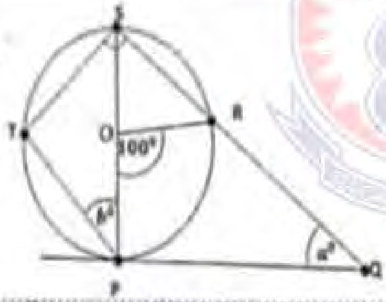
2∠PQR = ∠POR M1

y° = 2(80°) M1

y° = 160° A1

06

8



In this diagram, *PRST* is a circle with centre O. ∠ROP = 100°, 1

(A). Identify the property (ies), and write them down
(B). find ∠*PQR and* ∠SPT.**[6 MARKS]**

Properties = property 1, 3 and 6 ✓

∠SOR = 180 − 100 = 80° M1

~~∠~~SOR + 80 = 180

~~∠~~SOR = 180 − 80 M1

∠SOR = ~~100/2 = 50°~~ 80° A1

∠PQS = 40° = a ⟺ a = 40°

∠OSR + SRO + 80 = 180 M1

∠RSO = (180 − 80)/2 = 50

b = 90° − 50° = 40° M1 AD

05

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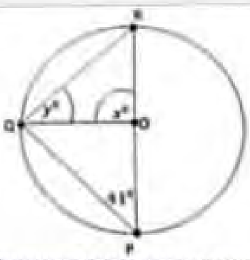
9.

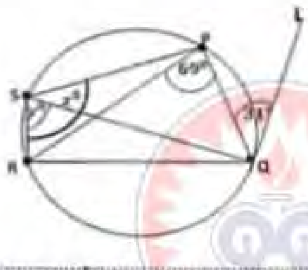


In the diagram, *PQR* is a circle with centre O and a diameter PR. $\angle QPO = 41^0$.

(A). Identify the property (ies), and write them down
(B). find $\angle RQO$ and $\angle ROQ$. **[6MARKS]**

Properties = Property 1, 3, 7 ✓
$2\angle OPQ = \angle ROQ$ M1
$2(41) = x$
$x = 82°$ M1 A1
$\angle OQR + ORQ + x° = 180$ M1
$2y° + 82 = 180$
$2y = 180 - 82$ M1
$y = \frac{98}{2} = 49°$ A1
06

10.



In the diagram, *PQR* is a cyclic quadrilateral $\overline{LQ}$ *is a tangent* . $\angle LQP = 31^0$, $\angle QPR = 69^0$.

(A). Identify the property (ies), and write them down
(B). find $\angle QSR$ and $\angle PSR$. **[6MARKS]**

Properties = property 2, 3, 4, and Eight ✓
$\angle TQP = \angle PSQ = 31°$ M1
$\angle QPR = \angle RSQ$ M1
$y° = 49$ A1
$\angle PSR = \angle PSQ + \angle QSR$ M1
$x° = 69° + 31°$ M1
$x° = 100°$ A1
06

Page 6 of 6

APPENDIX I

Marking Scheme of Post Achievement Test

QUESTIONS	DETAILS	MARKS
1	$2\angle SQR = \angle SMR$ $2(41^0) = a^0$ $a^0 = 82$ $\angle STR = \angle RQS$ $b^0 = 41$	M1 A1 M1 A1 **[4Marks]**
2	$\angle PSR + \angle PQR = 180^0$ $\angle PSR + 145^0 = 180^0$ $\angle PSR = 180^0 - 145^0 = 35$ $\angle PRS = 90^0$ $\angle RPS = 180^0 - (90 + 35)$ $\angle RPS = 55^0$	M1 A1 M1 A1 **[4Marks]**
3	$\angle SRP = \angle PQS$ $b^0 = 30$ $\angle QSP + \angle SPQ + \angle PQS = 180^0$ $a^0 + 30^0 + 80^0 = 180^0$ $a^0 = 180^0 - 110^0 = 70$ $a^0 = 70$	M1 A1 M1 A1 **[4Marks]**
4	$2\angle PSR = \angle PTR$ $2a^0 = 82$ $a^0 = 41$ $\angle QSP + \angle SPQ + \angle PQS = 180^0$ $\angle PQS = 180^0 - (90 + 41)$ $\angle PQS = 49^0$	M1 A1 M1 A1 **[4Marks]**
5	$2a^0 + 180^0 - 48^0 = 180^0$ $2a^0 = 180^0 - 132^0$ $a^0 = 24$ $b^0 = 90^0 - 24^0$ $b^0 = 66.$	M1 A1 M1 A1 **[4Marks]**
6	$\angle TPS + \angle TSQ = 180^0$ $\mathbf{y^0 + 120^0 = 180^0}$ $= 180^0 - 120^0$ $y^0 = 60$ $\angle RPT + \angle PTR + \angle TRP = 180^0$ $\mathbf{60^0 + 80^0 + x^0 = 180^0}$ $60^0 + 80^0 + x^0 = 180^0$ $x^0 = 180^0 - 80^0 - 60^0$ $x^0 = 40$	M1 M1 A1 M1 M1 A1 **[6Marks]**

7	$\angle PSR + \angle PQR = 180^0$ $\mathbf{100^0 + x^0 = 180^0}$ $x^0 = 180^0 - 100^0$ $x^0 = 80$ $2\angle PQR = \angle POR$ $y^0 = 2(80^0)$ $y^0 = 160$	M1 M1 A1 M1 M1 A1 **[6Marks]**
8	$\angle SOR = 180^0 - 100^0 = 80^0$ $\mathbf{2\angle SOR + 80^0 = 180^0}$ $2\angle SOR = 180^0 - 80^0$ $\angle SOR = 50^0$ $\angle PQS = 40^0 = a^0$ $\angle STP = \angle TPS + \angle PST$ $\mathbf{90^0 = b^0 + 40^0}$ $b^0 = 90^0 - 40^0 = 50$	M1 M1 A1 M1 M1 A1 **[6Marks]**
9	$2\angle OPQ = \angle ROQ$ $2(41^0) = x^0$ $x^0 = 82$ $2\angle QRP = \angle QOP$ $\angle QRP = 98/2 = 49^0$ $\angle QRO + \angle RQO + \angle QOR$ $= 180^0$ $49^0 + y^0 + 82^0 = 180^0$ $y^0 = 180^0 - 82^0 - 49^0$ $y^0 = 49$	M1 A1 M1 M1 M1 A1 **[6Marks]**
10	$\angle TQP = \angle PSQ = 31^0$ $\angle QPR = \angle RSQ$ $y^0 = 49$ $\angle PSR = \angle PSQ + \angle QSR$ $x^0 = 69^0 + 31^0$ $x^0 = 100$	M1 M1 A1 M1 M1 A1 **[6Marks]**

APPENDIX J

Pearson's Correlations Co- Efficient

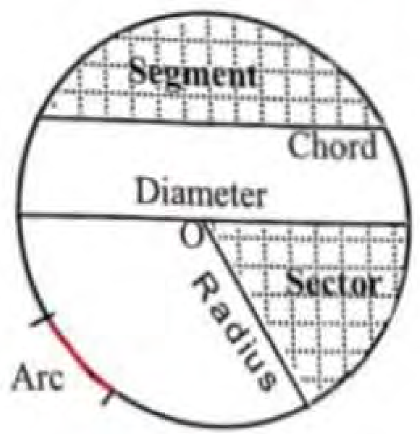
Reliability of Achievement test (spss output)

		ODD score	EVEN score
ODD score	Pearson correlation Co efficient	1.00	0.915
	Sig (2-tailed)		0.000
	N	24	24
EVEN score	Pearson correlation co efficient	0.915	1.00
	Sig (2-tailed)	0.000	
	N	24	24

APPENDIX K

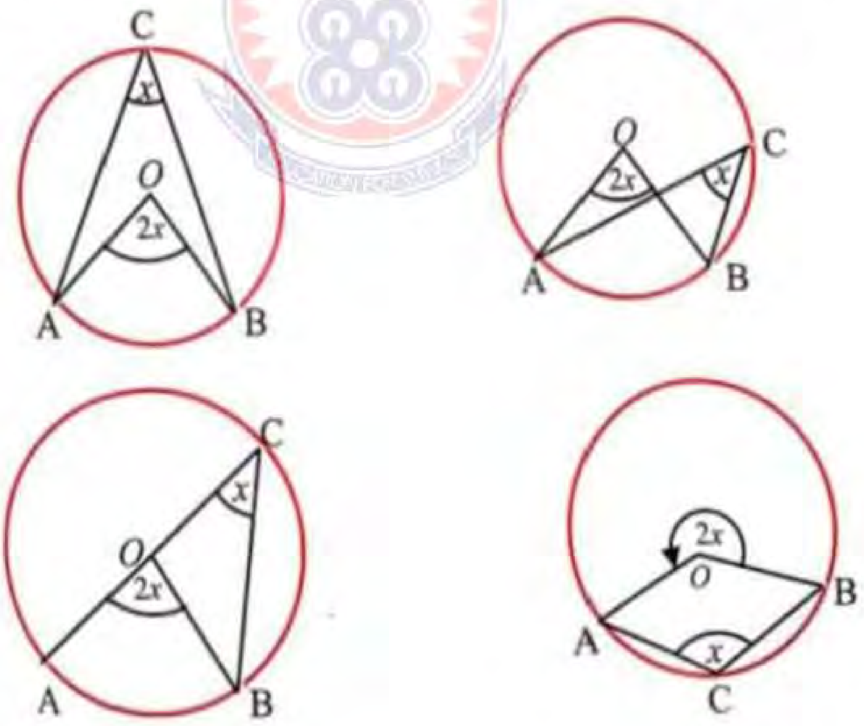
Circle theorem properties

CIRCLE THEOREMS

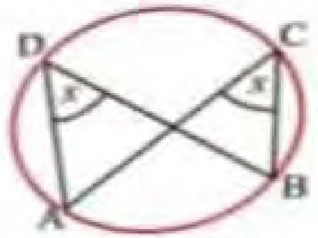


PROPERTIES

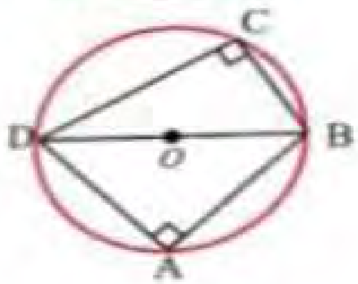
1. The angle at the centre of a circle is twice the angle at the circumference subtended by the same arc or chord



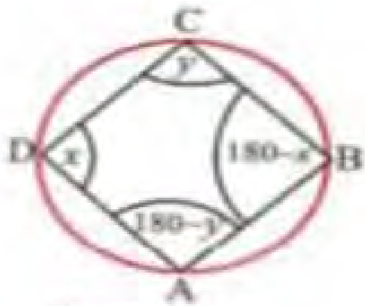
2. Angles subtended by a chord or arc in the same segment of a circle are equal. Alternatively, angles subtended by a secant at the circumference are equal.



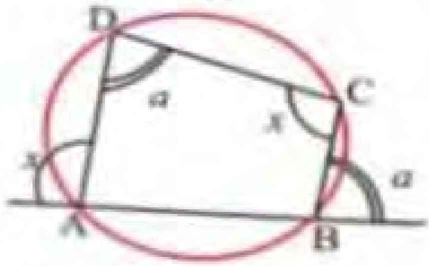
3. The angle in a semi-circle is a right angle.
Alternatively, we can say 'the angle subtended by the diameter on the circumference is 90°. O is the centre.



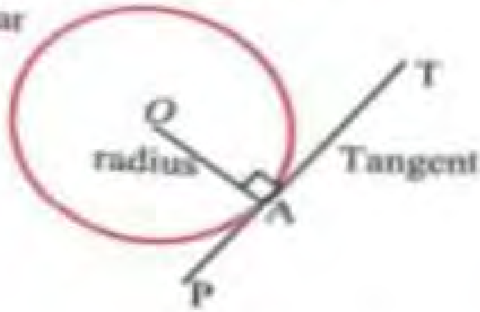
4. The opposite angles in a cyclic quadrilateral are supplementary.
Thus $y + 180° - y = 180°$ and $x + 180° - x = 180°$



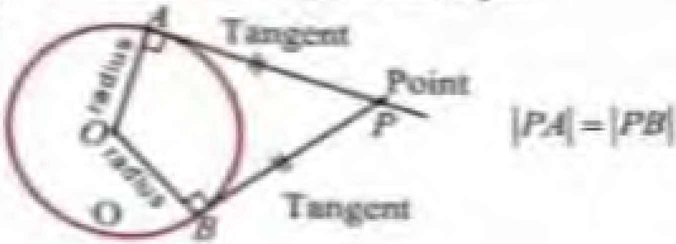
5. The exterior angle at a vertex of a cyclic quadrilateral is equal to the interior opposite angle.



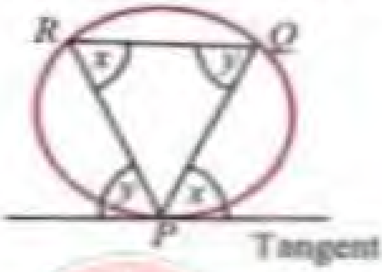
6. The tangent to a circle is perpendicular to the radius drawn from the point of contact.
Thus, $QA \perp PT$



7. Tangents to a circle from an exterior point are equal.
Thus, $|PA| = |PB|$

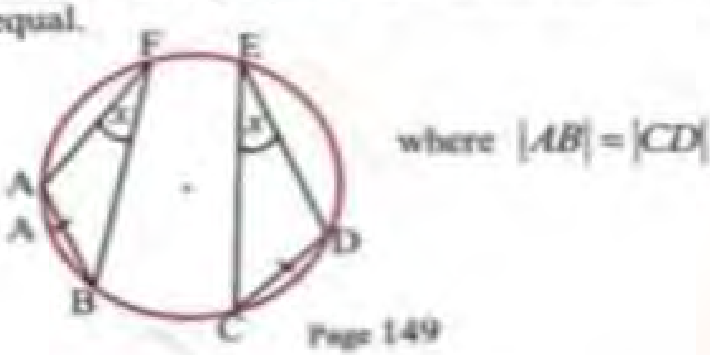


8. The angle between a tangent and a chord through the point of contact p is equal to the angle in the alternate segment.



9. The angles subtended by equal chords at the centre of a circle are equal.

10. The angles subtended by equal chords at the circumference of a circle are equal.



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APPENDIX L

Copy of Introductory Letter

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF MATHEMATICS EDUCATION

June 29, 2021

TO WHOM IT MAY CONCERN

Dear Sir /Madam,

LETTER OF INTRODUCTION: KAFUI KUGBLENU (200000075)

I write to introduce to you the bearer of this letter, Kafui Kugblenu, a postgraduate student in the University of Education, Winneba. He is reading for Master of Philosophy degree in Mathematics Education (M.Phil) and as part of the requirements of the programme, he is undertaking a research titled – ***investigating the effect of geogebra software on achievement of students of Anlo SHS, Anloga District.***

He needs to gather information to be analysed for the said research and he has chosen to do so in your institution. I would be grateful if he is given the needed assistance to carry out this exercise.

Thank you.

Yours faithfully,

Dr. Joseph E. Nyala
Graduate Coordinator

DEPARTMENT OF MATHEMATICS EDUCATION
UNIVERSITY OF EDUCATION
WINNEBA