UNIVERSITY OF CAPE COAST

EFFECT OF INDUCTIVE TEACHING METHOD ON SENIOR HIGH SCHOOL STUDENTS' ACHIEVEMENT IN CIRCLE THEOREMS

CONSTANT RICHARD SEGBEFIA

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BY

CONSTANT RICHARD SEGBEFIA

Thesis submitted to the Department of Mathematics and Information and Communication Technology Education of the Faculty of Science and Technology Education, College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy Degree in Mathematics Education.

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ..... Date: .....

Name: Constant Richard Segbefia

Supervisor's Declaration

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

Supervisor's Signature: ..... Date: .....

Name: Mr Benjamin Yao Sokpe

ABSTRACT

The study examines the effect of inductive teaching method on Senior High School students' achievement in circle theorems and whether students' gender influence their performance in circle theorems. A non-equivalent control group quasi-experimental design was employed. One hundred and sixty-two students from two schools in Keta Municipality in Volta Region participated in the study. The control group consists of 80 respondents and the experimental group consists of 82 respondents. The eighty-two students in the experimental group were taught topics in circle theorems using inductive teaching method while the eighty students in the control group were taught the same topics using conventional approach. Two research questions and two null hypotheses guided the study. At the beginning of the experiment a pre-test was administered to the students in the two groups while at the end of the experiment session that lasts for two weeks, a test was administered to the students as post-test. Data were analysed using frequencies, percentages, mean, standard deviation, ANCOVA and independent sample t-test at five percent significant level. The study revealed that those who were taught circle theorems using inductive teaching method performed better than those who were taught circle theorems conventionally. It further revealed that there was no significant difference in the performance of male and female students taught circle theorems using inductive method of teaching. The implication is that students' gender has no statistically significant effect on their academic performance in circle theorems. The study recommended that mathematics teachers should vary their classroom teaching practices, including inductive teaching method in mathematics.

KEY WORDS

Achievement

Circle theorem

Inductive Teaching method

Geometry

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DEDICATION

To my lovely wife, Ms Veronica Akpene Mifetu and children

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CHAPTER ONE

INTRODUCTION

Two concerns that have emerged in recent discussions of the educational system in Ghana are the overall decline in mathematics achievement at the Pre-tertiary level and the low patronage of Science, Technology, Engineering and Mathematics (STEM) programmes at tertiary level of education. As a remedy, many educational reforms have taken place by successive managers of education. However, the underlying issue is whether teaching and learning approaches used by Ghanaian teachers are good enough to stand a test of time (Enu, Nkum, & Agyeman, 2015).

This chapter provides the background to the study, the statement of the problem, the purpose of the study, research questions, research hypotheses and significance of the research, delimitations, limitations, and definition of terms and organisation of the study.

Background to the Study

Mathematics in all-purpose is a vital subject aimed at systematic and technological development of any state (Lakshmi & Kundarapu, 2018). In real life, mathematics plays a vital role in determining the future of young persons (Fatima, 2015) and so has become a portion of life deprived of which man could not function (Suratno, 2016). This indicates the significance of mathematics without which a nation does not grow scientifically and technologically; a signal that mathematics is crucial for science. Mathematics is the medium through which an individual's mind sharpens, reasoning ability and personality develops, hence its huge

contribution to the general and elementary education of people of the world (Appiah-Boateng, 2015).

Ministry of Education Teaching Syllabus for Senior High School core Mathematics has been structured to meet the demands of life. Specifically the curriculum is planned to assist the learner to:

a) Cultivate the abilities of picking and applying norms for classification and generalization.
b) Connect well with mathematical relations, symbols and descriptions via logical reasoning.
c) Practise mathematics in daily life by identifying and applying suitable mathematical problem-solving approaches.
d) Comprehend the procedure of measurement and use suitable measuring devices.
e) Advance the capability and readiness to do inquiries using several mathematical concepts and operations.
f) Work in union through other learners in carrying out tasks and assignments in mathematics.
g) Improve the standards and individual potentials of diligence, persistence, self-confidence, patriotism and tolerance through the reading of mathematics
h) Use information technology for problem-solving and investigations of real-life circumstances.

i) Cultivate a curiosity in learning mathematics to an advanced level in training for professions and careers in technology, science, industry, commerce, and a diversity of career areas.

j) Conceptualize ideas within the subject itself and in other disciplines, especially, Technology, Science, Commerce and Economics (CRDD. Ministry of Education, 2010).

The SHS Core Mathematics syllabus covers Plane Geometry I, in the first year and Plane Geometry II (circle theorms) in the second year, and Mensuration, Geometrical Construction including Loci, among others are treated in the third year (MOE, 2010). Plane Geometry covers areas such as angles at a point, exterior angle theorem, properties of parallel lines, special triangles, polygons, quadrilaterals, circle theorems and tangents and chords.

Geometry as an important division of mathematics consists of points, straight lines, plane figures, space, and three-dimensional figures and the relationships between them (Biber, Tuna & Korkmaz, 2013). Geometry as explained by Clapham and Nicholson (2009, p. 23) is "the area of mathematics related to the study of points and figures, and their properties". It is the study of shapes and spatial relationships of objects. Geometry is studied through basic school to the higher level of education in Ghana. The study of shapes and their properties aids us to see Mathematics as a portion of the things we experience and use every day. For example, symmetry which is a central part of geometry, nature and shapes form patterns that help us shape our world conceptually (Knuchel, 2004). The right learning of the concepts of shapes particularly solid shapes, and their properties

helps place a solid basis for the study of Mathematics topics such as mensuration, vectors, fractions, statistics and mechanics (Jones & Tzekaki, 2016).

According to Hidalgo (2017) teaching inductively naturally is psychological. Teaching inductively develops curiosity within the learners, which is very crucial for nation development. The inductive method of teaching is supported by Pestalozzi and Francis Bacon. This method of teaching is based on the procedure of induction in teaching-learning practices. In the world of mathematics, it is an approach of making a formula with a sufficient number of concrete, actual and real examples. By this approach of teaching mathematics, the students follow the content with serious attention and understanding at various levels. Inductive teaching approach is useful in algebra, geometry, trigonometry and arithmetic. Inductive teaching method proceeds from particular examples to general rules of formulae, concrete illustrations to abstract rules, known to unknown and simple to complex. Inductive teaching method is time consuming if not managed well.

Learning geometry as an area of mathematics in particular is said to be determined by gender differences. A few studies investigated the influence of gender on perceived difficult geometry concepts in mathematics and achievement have been conducted. Mutai (2016), argued that gender of students has effect on the learning of mathematics in favour of males. However, in an effort to examine whether the number of geometry concepts perceived difficult to study vary between male and female senior high school students, Fabiyi (2017) led a study in Nigeria of five hundred senior secondary school students and found out that gender of learners

had a significant impact on the learning of geometric concepts in favour of female students.

Statement of the Problem

All aspects of human life at diverse levels are affected by Mathematics as a subject. A way or a pattern of life can only be attained through the philosophy of mathematics. Unluckily, performance of students in mathematics over the decades has not been positive at the basic, secondary and tertiary levels of schooling in Ghana (Enu *et al*., 2015). Studies have revealed that students have difficulties in learning circle theorems (Adegun & Adegun, 2013; Weiss & Herbst, 2015). The Chief examiner's reports for WASSCE core mathematics from 2013 to 2018 suggest generally that, candidates had difficulties in solving problems involving geometry such as, cyclic quadrilaterals, chord theorem and circle theorem. The Chief examiner further states that the majority of candidates found it difficult solving problems concerning the concepts of exterior and interior angles of polygons and their properties, among other concepts (WAEC & GOG, 2019; WAEC, 2017).

Also, the researcher's observation during teaching and WASSCE 2016 through to WASSCE 2019 co-ordination and marking meetings also suggest that students' knowledge of plane geometry and mensuration is insufficient. For example, candidates have difficulties identifying similarities and differences among shapes, identifying properties of shapes and solving problems relating to concepts of circle theorems.

Students are admitted directly into SHS in Ghana based on Basic Education Certificate Examination (BECE) performance. A student must obtain at least, grade 8 in Mathematics to qualify for placement into SHS by the Computerized School Selection and Placement System (CSSPS) (Larnyoh, 2017). In Ghana, for an SHS student to gain admission into Colleges of Education, Polytechnics or Universities, the student must obtain at least grade "C6" or better in core Mathematics among others in the WASSCE. Therefore, Mathematics acts as a critical filter denying or giving access to many students to continue their study at the SHS level, Colleges of Education, Polytechnics and Universities (Mensah-Wonkyi & Adu, 2016).

Globally, Ghanaian mathematics students perform below standard of Trends in International Mathematics and Science Study (TIMSS) (Enu *et al.,* 2015). Though Ghana could not participate in TIMSS 2015, the recent low performances were justified in the previous TIMSS examinations in 2003, 2007, and 2011 when Ghanaian students held one of the lowest-ranked positions amongst the participating nations in mathematics achievement (Mullis, Martin, Foy, & Arora, 2012).

According to Akaboha and Kwofie (2016), students' performance in Mathematics at the BECE and WASSCE seems to be low over the years. An analysis to determine students' achievement in West African Senior School Certificate Examination was employed by Akaboha and Kwofie (2016) using one hundred and four (104) students who finished Suhum Senior High Secondary Technical School in 2013. Statistics of students Basic Education Certificate Examination grades in mathematics and distribution of their corresponding relative

achievement in the WASSCE were analysed. It is inferred that the better the BECE grade in Mathematics the better the performance in the WASSCE. The poor performance of secondary school students in the subject in Ghana is confirmed by the 2018 WASSCE results. Yeboah, (2018) reported that in a total of 314,401, candidates, 193,882 candidates representing 62 per cent failed to obtain grades A1 to C6 in core Mathematics in the 2018 WASSCE.

An observation was also made of results of the first one hundred students admitted into Anlo Afiadenyigba Senior High Schools during sorting of admission forms by the researcher (in 2019/2020 academic year). The distribution is shown in Table 1.

Table 1: **Distribution of BECE grades of students entering SHS**

Grade	Interpretation	Frequency	Percent (%)
3	High	1	1.0
4	High average	9	9.0
5	Average	11	11.0
6	Low average	26	26.0
7	Low	34	34.0
8	Lower	19	19.0
Total		100	100.0

Source: Fieldwork (2020)

Table 1 indicates that majority (53%) of the students who qualify for admission possessed very low grades of 7 and 8 in mathematics and only 10% of them had grades 3 and 4 in mathematics in BECE 2018. Even though BECE uses Stanine system, one can argue that many of these students admitted may have a weak

foundation in mathematics (Addadzi-Koom, 2012). These low grades in schools might lead to poor performance in WASSCE if not taken seriously (Akaboha & Kwofie, 2016). Most of these students enter the SHS with their perception of mathematics as being difficult and abstract.

The students' inadequate knowledge of geometry and students' poor performance at the SHS level may be related to poor entry grades. The students' insufficient knowledge in geometry and their weak performance in it, if not addressed, have the potential of creating great difficulties in attaining their future goals. Knowing the entering characteristics of the SHS students, it is possible a good teaching approach can help even weak students come up in mathematics by the end of the 3-year programme. This raises the research question bothering the mind of the researcher.

Teaching syllabus for Core Mathematics (CRDD, Ministry of Education, 2010) has circle geometry as a topic under Plane Geometry II to be treated at SHS2. The learners are likely to attain the following key specific aims in Plane Geometry II:

1. examine, state and use the circle theorems,
2. identify radius as perpendicular to the tangent at the contact point.
3. verify that the angle between chord and tangent at the point of contact is equivalent to the angle in the alternate segment.

Ghanaian students continue to perform poorly on circle theorems in WASSCE (WAEC, 2017, 2018).

A number of studies have been conducted to establish the impact or veracity of using inductive teaching methods in schools (Acharya, 2016; Atta, Ayaz, Nawaz,

& Khan, 2015; Ihedioha & Osu, 2012; Rahmah, 2017). But it appears they covered various disciplines except circle geometry. Furthermore, they worked on inductive teaching methods as a pedagogic approach leaving out its effect on the gender. This current study focused on the effect of the use of inductive teaching method on students' achievement in circle theorems and whether such effects depend on the gender of students.

Purpose of the Study

The research therefore, sought to examine the effect inductive teaching method has on SHS students' achievement in circle theorems and to determine whether such effects depend on the sex of students in the Keta Municipal.

Research Questions

The research questions that underpinned the study were as follows;

1. What is the effect of inductive teaching method on students' achievement on a circle theorems test?
2. What is the difference in the performance of male and female students taught circle theorems using inductive teaching method?

Research Hypotheses

Based on the research questions of study, the following null hypotheses were formulated for testing;

H_{O1}: There is no significant difference in the mean achievement scores of students taught circle theorems using inductive method and those taught using conventional instructional approach.

H_{O2}: There is no significant difference in the mean achievement scores of male and female students taught circle theorems using the inductive instructional approach.

Significance of the Study

The results of the research provides evidence on the benefits of using inductive teaching method in mathematics. This could be used as a guide to orientate and encourage other mathematics teachers at both first and second cycle institutions in the Keta Municipal to use the inductive method when teaching mathematics. Moreover, the research would help dispel students' general negative perceptions about geometry in particular and mathematics programmes.

Finally, the study would add knowledge to mathematics education and reference material at the library for mathematics educationalists and the general public.

Delimitation of the Study

This work was restricted to senior high schools in Keta Municipality, Volta Region of Ghana. The study was focused on only plane geometry II (Circle Theorem) from the senior high school form 2 Core Mathematics curriculum. Also, quantitative methods was used to obtain data on learners' progress when the experiment was being conducted. Therefore, the conclusions of the study are not to be extended beyond the subject matter of the study.

Limitation of the Study

This study employed quasi-experimental design. The use of unequal groups as control and experimental, created possible error in the data analysis due to non-

randomization of constituents of the study. Also the use of purposive sampling procedure to select senior high schools in Keta Municipal limits the generalization of the findings for all students in senior high schools in Ghana.

Definition of the Terms

*Achievement in circle theorems***:** Achievement, operationally is defined in terms of scores obtained by the students on a mathematics test.

Conventional approach: Conventional approach refers to the traditional way of teaching wherein most of the time lecture method is used. This method of teaching is teacher dominant, and textbook-centred. The emphasis here is mainly in remembering and reproducing facts, principles and theories of learning.

*Inductive Method***:** This is a teaching method aimed at building formula with the aid of an appropriate size of samples. Inductive method leads from concrete to abstract, particulars to generals and examples to formula.

*Deductive Method***:** A pre-created formula is said to a learner and they are asked to answer the relevant questions with the assistance of that formula. Deductive method leads from general to particular, abstract to concrete and formula to examples.

Organisation of the Study

The work was systematically planned in five different chapters. Chapter One presents an introduction, covering a background to the study, statement of the problem, the purpose of the study, research questions and hypotheses significance of the study, delimitations, limitations and finally organization of the study.

Chapter Two tackles the literature review of the study. Apart from the theoretical framework, this chapter reviews studies on the Concept of Geometry, Reasons for inclusion of Geometry in the School Mathematics Curriculum; Teaching and Learning Geometry; Challenges in Learning and Teaching Geometry; Teaching Geometry Inductively and Deductively; Influence of Gender and Performance in Geometry.

Chapter Three covers the research methodology comprising research design, population and sample and sampling procedure, research instruments, data collection procedure, data analysis procedure and ethical considerations.

Chapter Four consists of results and discussions, while Chapter Five includes the summary, conclusion and recommendations and suggested areas for further study.

CHAPTER TWO

LITERATURE REVIEW

The study sought to determine the effect of the inductive teaching method on senior high school students' achievement in geometry and whether students' gender influences their performance in geometry. The literature review sought to explore senior high school circle geometry content and common problems associated with circle theorem that make it a problematic topic for students.

The problems of teaching and learning geometry at the various levels of education have been researched into by many scholars both local and foreign. Several studies have indicated that students find it difficult to comprehend geometric concepts, which is an important aspect of learning mathematics. Some of these related research papers, published databases, reports, journals, and publications were reviewed to support the write-up. The literature review was intended to discuss findings on the teaching and learning of geometry inductively so as to identify gaps in current knowledge on the mathematics education at senior high school level in Ghana.

This chapter reviews literature on the Concept of Geometry; Reasons for inclusion of Geometry in the School Mathematics Curriculum; Teaching and Learning Geometry, Performance of Students in Geometry, Challenges in Learning and Teaching Geometry; Teaching Geometry Inductively; Influence of Gender on the Mathematics learning and Performance in Geometry.

Concept of Geometry

Geometry is the study of shapes and spatial relationships of the objects we see around us in the physical world. To the ancient Greeks, it literally meant "measuring the earth", from the words 'ge' meaning "earth" and "metreo" meaning 'measure' (De-Risi, 2015). Geometry has captured the attention of nearly every civilization throughout the ages (Scriba & Schreiber, 2015).

Geometry, as one of the greatest significant branches of mathematics, has a very important place in teaching and learning. Objects that we often see and use in our environs are made up of geometrical shapes and objects. Relating these objects and shapes resourcefully rests on knowledge of the relations among them. We also make use of geometrical views in answering problems (like artworks, lining-wall etc.), in describing the space and running our occupation as well. Geometrical shapes and objects are part of our professions. The operational use of the plane figures also depends meaningfully on the understanding of the relationship that connects the objects and their use (Serin, 2018).

A valuable modern description of geometry credited to the highly cherished British Mathematician, Sir Christopher Zeeman is "geometry comprises those branches of Mathematics that exploit visual intuition (the most dominant of our senses) to remember theorems, understand proof, inspire conjecture, perceive reality, and give global insight" (Johnston-Wilder, Johnston-Wilder, Lee, & Pimm, 2010). These skills can be said to be transferable and are needed for other areas of science and mathematics.

The Royal Society & Council (2001) submits that the purposes of geometry education can be summarized as follows:

a) To develop spatial awareness, geometrical intuition and the ability to visualize;
b) To provide a breadth of geometrical experiences in 2 and 3- dimensions;
c) To develop knowledge and understanding of and the ability to use geometrical properties and theorems;
d) To encourage the development and use of conjecture, deductive reasoning and proof;
e) To develop skills of applying geometry through modelling and problem-solving in real-world contexts;
f) To develop useful ICT skills in specifically geometrical contexts;
g) To engender a positive attitude to Mathematics; and
h) To develop an awareness of the historical and cultural heritage of geometry in society, and of the contemporary applications of geometry.

Considering the definitions and aims of teaching geometry as indicated above, one can argue for its inclusion in the school Mathematics syllabus.

Circle Geometry

Circle geometry is a division of mathematics involving properties of angles and lines within, on, and outside circles. Circle theorem is a subdivision of Euclidean geometry that includes the use of theorems, theorem converses, corollaries and axioms. The National Council for Curriculum and Assessment (Ministry of Education CRDD, 2010) Teaching Syllabus for Core Mathematics has circle

geometry (Plane Geometry II) as a topic to be learned by learners at the SHS2 level. Circle theorem is assessed in WASSCE, but students often perform below average in this topic (WAEC & GOG, 2019). Amongst major reasons accountable for poor performance in geometry include; wrong teaching and learning approaches used by teachers and lack of students' self-confidence and inspiration (Chimuka, 2017).

In the second year of Senior High School, learners are to accomplish three main specific aims in Plane Geometry II by the end of the teaching:

a) investigate,
b) state and use the circle theorems,
c) identify tangent as perpendicular to the radius at a point of contact,
d) verify that the angle between tangent and chord at a point of contact is equal to the angle in the alternate segment (Ministry of Education, 2010).

This study sought to determine the efficacy of using inductive teaching method and its effect on Senior High School students' achievement in geometry.

Inclusion of Geometry in the School Mathematics Curriculum

The Chambers Harrap Pub. Ltd (2011) explains curriculum as a course of study at a school, college, university etc. Su (2012) critically study literature related to the word "curriculum." and refers to curriculum as coming from Latin word, meaning to "run a race track". (Ministry of Education CRDD, 2010) Curriculum in education is a combination of the learning outcome, pedagogy and content that students are to address. Su (2012) then, claims that there was a need to reconsider a wider range of "curriculum" that welcomes the entire phases in the curriculum development

process—objectives, content, methodology, and assessment of learners, especially when a curricular review or assessment is done**.**

The introduction and implementation of a new mathematics curriculum in 2007 was grounded on the twin reasons that every learner needs to study mathematics and every learner is capable of learning mathematics. The rationale is to allow all learners' to obtain the mathematical skills and values required to be successful in their preferred vocations. The new curriculum inspires the attainment of new talents which make instructional approaches and aids to assist learners mature mathematically (Ampadu, 2014).

Accordingly, the geometry learning pays to assisting learners "develop the skills of visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof" (Jones, 2014, p.12) Geometrical images could be a source of support to learners to grasp the concepts of fractions and multiplication in arithmetic, graphical representations of data in statistics, and graphs of functions as other branches of mathematics. (Jones & Tzekaki, 2016).

Moreover, we live on planet Earth, in a 3-dimensional world where more of our experiences are through visual stimulus. The ability to interpret visual information is fundamental to human life. Geometry presents a significant way of developing visualization skills. Visualization helps scholars to discover mathematical concepts with ease, deprived of the need to draw exact diagrams or symbolic representations (Jones, 2014).

Baykul as cited in Serin (2018 p.21) states geometry is a rich source of opportunities for developing notions of proof". It is a tool that helps learners to entertain themselves and even encourage students to have interest in mathematics through games of geometrical shapes. Operation of visual images on the computer screen invite learners to observe and conjecture generalizations. In verifying conjectures, learners are required to have knowledge of how the images are related to each other, and in having knowledge of observed images, means working with points, circles, polygons, parallel and perpendicular lines, and so on.

Since most of our traditional, social and ethnic life-style is real, our visual appreciation of art, architecture, music and many of our cultural artefacts involves geometric principles and concepts such as symmetry, perspective, scale, and so on. Our textiles industry for instance, applies a lot of geometric principles and concepts in the designing and production of their products.

Geometry offers an artistically and factually rich context in which we learn mathematics. Many exciting, sometimes astonishing results in geometry motivate learners who want to acquire knowledge culturally and historically are crafted. Learning geometry through the right medium inspires curiosity and encourages exploration that enhances learner' perception and attitudes towards mathematics (Abdullah & Zakaria, 2011). By inspiring learners to debate problems in geometry, formulate their ideas and develop clearly organized arguments to support their ideas leads to enhancing communication skills and recognition of the significance of proof (Serin, 2018). Creativity is a special gift from God and God uses a variety of shapes in His wonderful creation. The expression of creativity through art can be

viewed as an act of praising God. The impact of mathematics to learners' spiritual, moral, social and cultural upbringing can be successfully realized via geometry.

Finally, many new applications of mathematics have solid geometric components. Recently, difficulty of getting 'geometric' materials into a computer in a useful format. To answer geometric questions, and outputting solution as a visual or spatial form as a design to build, had reduced drastically. But answering these questions require extensive geometric knowledge (Jones, 2014).

Teaching and Learning of Geometry

Geometry, as a division of mathematics, needs abstract thinking. Students are abstracted or troubled for intangible motive, a typical indication that the tutor failed to use a suitable teaching method, making teaching and learning ineffective. Educational training institution's pedagogical content knowledge is dealt with inadequately (Ottevanger, Akker, & Feiter, 2007; Wilmot, Yarkwah, & Abreh, 2018). A pedagogical method can be highly effective in the teaching a branch of mathematics but may not be effective in the teaching of geometry (Abdullah & Zakaria, 2011). Hence geometry educators must to strategize classroom activities in a way that will assist the students to realize the nature and the concepts of geometry.

Teaching Geometry can be done using different activities. Choosing a specific activity is guided by the objectives of the lesson. Such activities usually have an impact on how students learn geometry because the teaching of secondary school geometry is a dedicated practice, branded by its own practical rationality which

should not be taken as the equivalent to that of research mathematics (Weiss & Herbst, 2015). A typical way of learning geometry is through the inductive method.

International as well as local organizations or associations have been involved in various tasks concerning mathematics in schools. For instance, Japanese Overseas Voluntary Co-operation (JOVC) sends some of their teachers to some of the secondary schools to help in Mathematics and Science Education. Ghana Mathematics Society (GMS) and Mathematical Association Ghana (MAG) organise periodic seminars in the nation to sensitized educators on the significance of mathematics in nation building. As a result, improve mathematics education in both junior and senior high schools (Tetteh Korkor, Wilmot, & Ashong, 2018).

Teaching Geometry inductively

It is a huge priority for a teacher to provide a rich learning environment to students for successful lesson delivery because learner achievement in mathematics improves mostly by how real their tutors deliver subject content (Chimuka, 2017). Diverse ways of teaching mathematics have been suggested by different educationalists and these approaches geared towards developing a better mathematics teaching approach. A mathematics teacher adopts method of lesson delivery to match the level, interests and maturity of students. Every technique of teaching has certain advantages and disadvantages.

Mintah (2016) indicates some specific methods of teaching mathematics. These methods include; Inductive-Deductive Method, Lecture Method, Heuristic Method (Discovery or Inquiry Method), Project Method, Analytical-Synthetic Method, Brainstorming, Learning by Doing, Think-Pair-Share, and Problem Solving

Approach. This study examines the effect of inductive instructional methods on students' achievement in geometry and to explore the extent to which such effect depends on the gender of students in Senior High Schools in the Keta Municipal. According to (Hidalgo, 2017) teaching inductively naturally is psychological—develops curiosity within the learners, which is very crucial for nation development. Inductive method is a teaching method aimed at building formula with the aid of an appropriate size of samples. Inductive method leads from concrete to abstract, particulars to generals and examples to formula.

Like the discovery approach where learners practically manipulate geometric figures to identify their properties as well as the Cartesian plane to determine images from pre- image (Serin, 2018), the inductive teaching method or process goes from the specific to the general and may be based on specific experiments or experimental learning exercises (Atta *et al*., 2015). Students are taken through suitable activities involving varying but relevant examples so that they can make their observation and generalization. The generalization is refined by the teacher in line with the rule or formula to be learnt.

In contrast to the inductive teaching method is teaching deductively. According to Atta *et al*. (2015) the deductive approach usually takes place in huge classroom settings whereas the inductive approach is efficiently used in relatively smaller clusters or numbers of learners. The deductive approach is conventional, organized, and expectable outcome whereas the inductive approach is modified and the concepts are easily learned, recalled and applied. The deductive technique is a process of verification that comes from a source whereas the inductive technique is

a method of finding and relies on a learner's perspective or understanding of a concept.

Atta *et al*. (2015) further examined the achievements of the basic school students in mathematics when taught deductively and inductively. Thirty respondents were selected from six public schools and put the schools into two groups experimental and control. The study found that there was a statistically significant difference between the performances of respondents in the two groups. After the control group was taught deductively and the learners of the experimental group were taught mathematics inductively under a controlled environment, the experimental group did achieve higher scores than the control group.

A study by Acharya (2016) on measuring the effectiveness of the inductive method in teaching geometry at secondary school level, where he selected two groups and taught them the same topics in Geometry inductively and deductively revealed that the inductive method of teaching had better achievement results than that of the deductive method of teaching. The experimental group was taught geometry inductively and the control group was taught geometry deductively. The inductive and conventional teaching methods and achievement test were the main intervention instrument and tools respectively for the study. The mean, standard deviation, variance and t- test were used as statistical tools for the study. After analysing the obtained data, Acharya concluded that the inductive method of teaching had better achievement result than that of the deductive method of teaching.

Ihedioha and Osu (2012) also, explored the efficiency of inductive inquiry and the transmitter of knowledge models on learners' academic achievement on circle geometry and trigonometry. The inductive inquiry teaching method was established to be superior as compared to transmitter of knowledge models. Ihedioha and Osu suggested that inductive inquiry teaching should be used for circle geometry and trigonometry lesson delivery in second cycle institutions.

On the other hand, to determine the effect of using inductive and conventional method for mathematics lessons and mathematical problem-solving ability, Rahmah (2017) conducted an experimental quantitative study that emphasized on improving mathematical concept and problem-solving for JHS pupils by inductive to deductive teaching. The result has shown that learning mathematics by using inductive to deductive method could not increase pupils' mathematical problem-solving ability significantly compared to traditional teaching.

These inspired the need to go into the current investigation on the effect of inductive instructional method on students' achievement in geometry and to explore the extent to which such effect depends on the gender of SHS students in the Keta Municipal.

Influence of Gender on Mathematics learning

Learning geometry as an area of mathematics in particular is said to be determined by gender differences. A few studies investigated the influence of gender on perceived difficult geometry concepts in mathematics and achievement have been conducted. An international assessment aimed at helping countries to make decisions about how to develop mathematics and science education conducted

by TIMSS in 2015 for eight grade students showed little difference by gender in mathematics achievement of 39 participating nations. In seven countries, female students had higher achievement points in mathematics, with a mean difference of 17 points and male students had higher average achievement points in six countries, with a mean achievement of nine points. There was, however, no disparity in higher achievement points of boys and girls in 26 countries (Mullis, Martin, Foy, & Hooper, 2016).

Mutai (2016) also, argued that gender of students has effect on the learning of mathematics in favour of males. Males dominated institutions that achieved higher performance in mathematics as a result of the stronger affinity and interest in the learning of mathematics, Mutai re-emphasized that learning geometry is said to be determined by gender differences of students.

However, in an effort to examine whether the number of geometry concepts perceived difficult to study vary between male and female senior high school students, Fabiyi (2017) led a study in Nigeria of five hundred senior secondary school students and found out that gender of learners had a significant impact on the learning of geometric concepts in favour of female students. This view was supported by Erdogan, Baloglu, and Kesici (2011) that females achieve significantly higher in geometry than males.

Nevertheless, several studies were of the opinion that gender has no specific effect on the learning of mathematics (Adegun & Adegun, 2013; Arhin & Offoe, 2015; Yarkwah, Arthur, & Donkor, 2020). Adegun and Adegun (2013) investigated the effect of gender on learners' perceived levels of difficulty of

general mathematics concepts in the secondary school mathematics curriculum, and noted that, there were no disparities in the achievement of boys and girls in geometry. In support of Adegun and Adegun's (2013), argument, Tetteh-Korkor *et al*. (2018) indicated that there were no statistically significant differences in performance between male and female students under a training programme to become teachers in mathematics.

This also explores the extent to which the influence of students' gender affect performance of students who learn circle theorems through inductive teaching method in Senior High Schools in the Keta Municipal.

Performance of Students in Geometry

Even though, several studies have been done by mathematics educators which aimed at finding solutions to the main difficulties associated with teaching and learning of mathematics in schools, the problem of low achievement in mathematics has continued to be most country's public examinations worry (Adolphus, 2011). Poor teaching and learning methods employed by teachers could be the reason accountable for the poor achievement in mathematics.

Globally, Ghanaian mathematics students perform often below standard *(*Enu *et al.*, 2015). Though Ghana could not participate in Trends in International Mathematics and Science Study (TIMSS) in 2015, the recent low performances were justified in the last three TIMSS survey 2003, 2007, and 2011 when Ghanaian students held one of the lowest-ranked positions amongst the participating nations in grade eight mathematics achievement (Mullis *et al*., 2012). The report revealed that Ghanaian students performed abysmally in areas including Measurement,

Geometry and Algebra. Hence, the introduction of more stringent rules on teaching and learning of Geometry.

Davis *et al*. (2019) investigated the effects of grade levels on what Ghanaian school children find vital in their mathematics education. The study comprising 1,256 basic school and high school students was carried out in the Cape Coast Metropolis of Ghana. The survey found that the students in Ghana appreciated characteristics such as achievement, the use of ICT, and approaches of learning of mathematics but performed poorly on geometric concepts. They recommended mathematics should taught and learned via appropriate medium.

According to Adolphus (2011) students' bad performance in geometry are caused by factors such as poor mastering of subject content by teachers, wrong teaching approaches adopted by teachers, unconducive teaching and learning environment, among others. To examine policies that could reduce the problem of teaching and learning of geometry, Adolphus (2011), recommended that as a matter of urgency the state should organize in-service training and seminar programmes on teaching and learning of geometry for teachers. However, no teaching method was suggested.

Many mathematics educationists strongly believe that learners learn better if they discover the concepts by themselves rather than from traditional ways of learning mathematics. Under the guide of Constructivist theory, Ngonyofi & Ndeukumwa (2017) tried to explain geometric concepts using Understanding-by-Design teaching approach. The outcome was statistically significant in terms of learner performance on Geometry topics in favour of the Understanding-by-Design

instructional style. They recommended that, the teaching approach for Mathematics teachers when delivering a lesson on Geometry topics should include Understanding-by-Design.

In view of students' poor performance in circle theorems and their teachers' inability to vary their classroom teaching methods, Mensah-Wonkyi and Adu (2016) wanted to find out whether or not the introduction of the inquiry-based teaching approach will improve students' knowledge of circle theorems. They used mixed method research approach that employed quasi-experimental design on 79 home science learners in two intact classes. The study found that learners in both groups exhibited an improvement in the understanding of circle theorems in the post test as compared to the pre-test. Nevertheless, students taught circle theorems through inquiry-based teaching approach achieved better results compared to those taught with the conventional teaching approach. Mensah-Wonkyi and Adu suggested amongst others that inquiry-based teaching method should be incorporated into classroom teaching and learning.

Asemani, Asiedu-Addo, and Oppong (2017) conducted study into the measure of Van Hiele's levels (1 Visualization or Recognition, 2 Analysis, 3 Ordering, 4 Deduction and 5 Rigor) of geometric reasoning attained by final year students in Ghanaian before exiting SHS. A sample of 200 respondents from three schools were used. The study showed that 42.5% of the participants could not attain any of Van Hiele's level at all, 33% reached Van Hiele's level 1 (Visualization or Recognition), 22.5% reached level 2 (Visualization or Recognition and Analysis), 1.5% reached

level 3 (Visualization or Recognition, Analysis and Ordering) and only 0.5% reached level 4 (Visualization or Recognition, Analysis, Ordering, and Deduction).

Following the outcome of the analysis, it arose that, the highest probable Van Hiele's level attainable by a learner leaving secondary school in Ghana is level 3 (Ordering). The result further showed that, most of the SHS form 3 students in Ghana do not attain any level of Van Hiele's Geometry Test. This condition leaves the learners in Ghana not being competitive with other mathematics students in the rest of the world where geometry is essential to be taught and learnt up to Van Hiele's level 4 (Deduction). Higher institutional mathematics is more abstract and conceptual, and seriously founded on the basis of deductions. As a result, any student who enters institutions of higher learning is expected to think at Van Hiele's level 4. The study therefore, recommended that workshops and seminars should be organized for mathematics teachers on the Van Hiele's Model.

Challenges in Teaching and Learning of Geometry

In an attempt to find factors that influence students' achievement in geometry as an area of mathematics, Mamali (2015) investigated how learners perform in secondary school Euclidian Geometry. From the result, conducive teaching and learning environment, geometry teaching and learning resources, learner attitude and interest, and teacher's knowledge of geometry contributed hugely to learners' performance in geometry. Lack of infrastructure and facilities made it tough for any proper teaching and learning activity. Unconducive learning environment might make students loss interested in geometry.

Contribution of class size to learners' performance in Geometry is very significant. Too large a class turn to have a bad influence on students' performance in geometry (Suleiman & Hammed, 2019). The Ministry of Education (2018, and 2019) outlines the teacher-student ratio of one teacher per twenty- five students at the SHS level, but fixing the number of students per class at 40 maximum.

According to Assan-Donkoh, Susuoroka, Baah, Baah-Duodu, and Puotier (2019), senior high schools students' performances are generally poor in mathematics. Factors attributed to students' poor performance in mathematics in Ghana includes: inadequate teaching and learning material; negative teacher-student attitude towards the subject; and inappropriate teaching approaches. Other factors include an inadequate number of qualified teachers in mathematics, lack of teaching resources, improper transfer of mathematics teachers from one institution to another, poor socio-economic background of the learner, poor teaching method as well as over-enrolment of learners in the classroom (Suleiman & Hammed, 2019). (Adolphus, 2011) also identified the language factor of geometry. Language which contains specific terminology, is exceptional and needs specific consideration and knowledge before it can be used meaningfully. Wrong use of geometry terminology could cause misconceptions of geometry knowledge. Also, geometry needs visualizing abilities but many learners cannot visualize 3-dimensional objects in a 2-dimensional perspective. Hence they lack ample prior concrete understandings with solid objects. Learners might not have sufficient privilege to improve and exhibit spatial intellectual skills for active geometry education because of limited geometric experiences.

Additionally, the traditional methods of geometry instruction do not seem to assist learners achieve the intended learning results in the syllabus (Ngonyofi & Ndeukumwa, 2017). Classroom geometry experiences impede optimal learning by using just textbooks and chalkboards. Therefore, the traditional style of geometry instruction needed to be changed to one that is more satisfying for both teachers and learners. Precisely, students must be given opportunities to personally search and discover geometry to allow understanding of the subject in deepness and also in association with other branches of Mathematics. This suggests inductive approach as one of such teaching approaches intended to help in addressing the issue.

The major problem with many geometry students is poor geometry language proficiency. Perceptive geometric name like "tangent" and "chords" might not suggest that the learner understands their particular meanings or their properties involving angles. Obviously, geometry language, specifically in the understanding of geometry terms, plays a very significant role in learning and comprehension of geometric concepts (Mensah-Wonkyi & Adu, 2016). Asemani *et al*. (2017) in their work on the van HieIe levels of geometric thinking attained by Ghanaian final year students before exiting Senior High School, revealed that the failure of students to advance the level of thinking might be linked to students' deficiencies in geometric vocabulary.

Ability to visualize, as said earlier, is a pertinent problem of geometry learning. Various concepts in geometry entail learners to visually observe the objects and identify their properties by comparing them with their previous experiences involving similar objects. Geometrical concepts require visual interpretations as

several geometry problems are presented in a 2-dimensional format on paper. Thus learners who are unable to extract geometric information about 3-dimensional solid objects drawn on paper will face difficulty in interpreting questions involving solid geometry (Mensah-Wonkyi & Adu, 2016).

Many mathematics researchers recommend more visual activities in the classroom to help students understand geometric concepts. By being able to "touch-see-and-do" and interaction with the objects learning, learners can learn geometry in a more imaginative and successful way (Chimuka, 2017).

In the former, teaching and learning of geometry were considered as learner copying diagrams and properties of figures and shapes from blackboards and doing boring exercises to calculate angles, lengths, and areas of geometric figures. This method gave problems to both teachers and learners. Mathematics teachers became irritated because teachers' bad conceptual comprehension leads to poor geometry performance of students. Even in several classrooms in Ghana today, teachers introduce students to facts about Euclidean geometry and then drill them with concepts in deductive reasoning. Learners are occasionally given the opportunity to discover and conceptualize geometry on their own.

However, for effective teaching of geometry, the approach should not be the same as in teaching algebra or probability. Instead, teaching should emphasize conceptual discovering, developing geometric thinking and reasoning, conjectures and even carrying out geometry projects (Atta et al., 2015). The issue of poor performance in mathematics examinations was due to the problem of teaching methods. An investigation on factors causing low achievement in Geometry at

WASSCE level revealed that, teachers only aimed at covering a lot of topics in the syllabus, hence not teaching the topics well (Chisenga & Mulenga, 2019).

There is therefore a need for teaching strategies that arouse students' interest to learn mathematics and hence improve the quality of outcomes in mathematics classrooms. Investigating the use of inductive instructional method and its effect on students' achievement in geometry thus comes to mind. This study seeks to do that and to explore the extent to which such effect depends on the gender of students in Senior High Schools in the Keta Municipal.

Theoretical framework

This research is skewed toward the wide spectrum of constructivism. Constructivism is traced to the works of Piaget, Vygotsky and Bandura. Constructivism could be clarified as an epistemological opinion which perceives the student as an active participant in the teaching and learning process. The building of new knowledge happens at an existing framework, such as culture, religion, social, economic or a geographical setting.

Moreover, the study seems to be prepared on the principle of individuals creating their sense of new information or knowledge offered to them on the basis of their prior knowledge as determined by the learning environment. The new skills are used by the individual to construct new sense out of what is provided. According to Van Der Veer (1986), new knowledge construction is shaped through social interactions with elements in the community. This study therefore, adapted inductive teaching method framework from Shaffer (1989)(see figure 1).

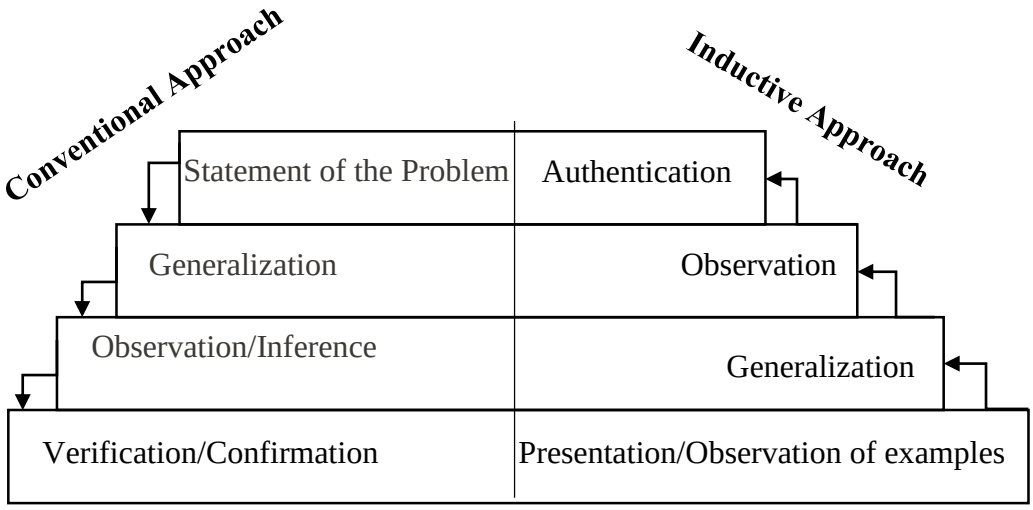


Figure 1: Conceptual framework of the Study

Source: Shaffer(1989)

Inductive approach

According to Hidalgo (2017) teaching inductively naturally is psychological. Teaching inductively develops curiosity within the learners, which is very crucial for nation development. The inductive method of teaching is supported by Pestalozzi and Francis Bacon. This method of teaching is based on the procedure of induction in teaching-learning practices. In the world of mathematics, it is an approach of making a formula with a sufficient number of concrete, actual and real examples. By this approach of teaching mathematics, the students follow the content with serious attention and understanding at various levels. Inductive teaching approach is useful in algebra, geometry, trigonometry and arithmetic. Inductive teaching method proceeds from particular examples to general rules of formulae, concrete illustrations to abstract rules, known to unknown and simple to complex.

Steps in an inductive teaching approach

The use of an inductive teaching method, progresses through the steps that follw;

1. Presentation of examples—the teacher shows examples of the same type, and obtain solutions of all those specific examples with the help of the student.
2. Observation/Reflection—the students detect and observe these examples and try to reach some conclusion.
3. Generalization (Simplification)—the educator assists students to solve common rules, laws, formulae or principle by logical mutual discussion.
4. Testing and verification (authentication)—the teacher takes students through the test and assists them to prove the law, rule or principle.

These help students to logically achieve the knowledge by an inductive teaching method.

Conventional Approach

Conventional approach refers to the traditional way of teaching wherein most of the time lecture method is used. This method of teaching is teacher dominant, and textbook-centred. The emphasis here is mainly in remembering and reproducing facts, principles and theories of learning. Conventional approach generally based on deduction. In deduction, teaching progresses from general to particular and from abstract to concrete. The teacher gives out the rule, principle or law to the learners and the teacher then guides the learners to know rule, principle or law. First of all, the rules are given and then learners are requested to apply rules to answer more

problems. Algebra, Geometry, Arithmetic and Trigonometry can be taught deductively. A deductive teaching method is used for teaching mathematics in junior high schools, senior high schools and higher educational institutes. Teaching deductively proceeds from general (rules, laws, principles or formula) to specific (examples), unknown to known, abstract law to concrete example and complex to simple.

Steps in a conventional approach

From figure 1, teaching deductively follows these steps;

a) Statement of the Problem
b) Generalization
c) Observation/Inference
d) Verification

In conventional teaching, the teacher gives the learner a new concept, explains it, and then asks the learner to practise using the concept (Hidalgo, 2017).

Summary of Related Literature

The present study reviewed literature that shows various studies that have provided many insights into methods of teaching and learning of geometry. There has been much attention on the teaching and learning of geometry in general, but there is a little focus on comparing inductive teaching approach in teaching of geometry to the conventional teaching method. The present study is original in its focus on the use of inductive instructional method and its effect on students' achievement in geometry and to investigate whether a student sex influences their achievement in geometry.

Implication of the Literature Review

The literature discusses that using inductive method as a pedagogic technique for teaching was very beneficial. However it has some challenges as well. Although there are challenges that confront the use of inductive teaching method as a pedagogic technique, a hundred miles journey starts with the first step. Challenges could be overcome thereby using inductive teaching method to promote child-centred mathematics education. The question that arises was how can mathematics teachers develop and improve students' geometric conceptual abilities through the use of inductive teaching approach?

CHAPTER THREE

RESEARCH METHODS

The study sought to examine the effect of the inductive teaching method has on students' achievement in circle theorems and to determine whether such effects depend on the sex of SHS students in the Keta Municipal. This chapter shows how the research was carried out, covering research design, population, sample and sampling procedure, research instruments, data collection procedure, data analysis procedures, ethical considerations and COVID-19 safety and health protocols observed during the data collection.

Research Design

The quasi-experimental (Pre-test-Post-test) non-equivalent control group design was employed. This design was necessary and suitable for the study since the setting of study prohibit the formation of artificial groups. It is a non-equivalent comparison-group design and is amongst the most regularly used quasi-experimental designs. A quasi-experiment is an empirical study used to evaluate the causative-and-effect treatment activity on the target population without random assignment so as not to disrupt school classes (Achor & Agamber, 2016). There is no randomization of respondents into treatment and control groups. This study usually started with a pre-test on two randomly selected intact groups often referred to as experimental and control groups. This was followed by a treatment for a period of two weeks after which a post-test was carried out on the two groups (Creswell, 2012). This design is specifically used since it determined the effectiveness of using the inductive teaching method on students' achievement.

The design is graphically represented as shown;

Pre-test	Treatment	Post-test
$\boldsymbol{P_1}$	$\boldsymbol{Y_1}$	$\boldsymbol{P_2}$
$\boldsymbol{P_1}$	$\boldsymbol{Y_2}$	$\boldsymbol{P_2}$

where:

a) P_1 is the pre-test for the treatment and control groups

b) P_2 is the post-test for the treatment and control groups

c) Y_1 is the inductive teaching approach used to teach the treatment group

d) Y_2 is the conventional teaching method used to teach the control group.

In applying the non-equivalent pre-test-and-post-test design in this study, the dependent variable (geometry achievement) was measured before and after the treatment. This enabled the investigator to find the sequential precedence of the independent variable (inductive teaching method and conventional teaching method) over the dependent variable and measure between group differences before the treatment. The progress of the treatment gave the investigator more self-confidence when making an interpretation to the effect that the independent variable would be accountable or not for changes in the dependent variable and use the pre-test to measure between-groups differences before the introduction of the treatment, which decreased significantly the risk of selection bias by revealing whether the groups changed on the dependent variable prior to the treatment (Creswell, 2012).

The investigator assigned whole groups as the treatment and control. The researcher administers a pre-test to both groups, conducted experimental activities with the treatment group, and then administered a post-test to measure the variation between the two groups.

Study Area

Second-year senior high school students (all of whom take core mathematics) in Keta Municipal were sampled purposively for the study. The study area was Keta Municipal. The selection of the municipal was based largely on proximity, convenience, familiarity and accessibility to the researcher. The researcher, having taught in the municipal for some years, is familiar with many of the schools and as such has easy access to the needed information that made data collection effective.

Keta Municipal is one of the seventeen districts in the Volta Region of Ghana. Keta is the Municipal capital and administrative centre. The population of the Keta Municipality is about eighty-two thousand (82,000). Land space area is about $182\ km^2$ with a population density of $450.0/km^2$. Keta has a humid savannah weather with a monthly average hotness of above 18°C (Ghana Statistical Services, 2020). The Municipal is bounded by the Gulf of Guinea to the south and southeast, Anloga District to the west, Akatsi South District to the northwest, Ketu North District to the north and Ketu South Municipal to the northeast.

The people are typically fishermen, farmers, traders, businessmen, unlicensed salt mineworkers and government employees. Major languages spoken are Ewe and English (Ghana Statistical Services, 2020). Keta Municipal is made up of the following towns:

Abor,	Atiteti,	Keta,
Anlo Afiadenyigba,	Dzelukope,	Seva ,
Anyako,	Hatorgodo,	Tsiame,
Asadame,	Horvi	Vodza,
Atiavi,	Kedzi,	Weme

Population

The population for this work was the entire second year students from the seven senior high schools in the Keta Municipal. There were 2750 SHS2 students in Keta Municipal for 2019/2020 academic year. The choice of this population was necessitated by the selected topic—circle theorems, which according to the Ministry of Education, (2010) is learnt in SHS2. Second year students have some previous knowledge of plane geometry—angles at a point, angle properties of parallel lines, relationships between corresponding angles, vertically opposite angles, alternate angles and adjacent angles, supplementary angles, and exterior angle theorem—learned in SHS1. The mean age of the second year students was seventeen years all of whom are BECE holders. There are seven public senior high schools in the municipality; one GES category B school, four are GES category C schools and the rest are GES category D schools. All the schools are mixed-sex schools. There are no private senior high school in the municipality. The students are from all the sixteen regions of Ghana, with the majority coming from the Volta region.

There were two thousand seven hundred and fifty (2,750) SHS2 students in the municipality. One thousand four hundred and fifty-six (1,456) are females and one thousand two hundred and ninety-four (1,294) are males.

The target population was all second year students from the two schools involved in the study. There were 519 SHS2 students in 2019/2020 academic year. This consists of two hundred and seventy-six (276) students school A and two hundred and forty-three (243) students in the school B.

Sampling Procedure

Sampling refers to the procedure of choosing a percentage of the population to depict the whole population (Alvi, 2016). Sampling procedures for the determination of this study was a mixture of convenience, purposive and stratified random sampling. Convenience sampling is a type of nonprobability sampling in which people are sampled simply because they are "convenient" source of data for the researcher. Purposive sampling was based on deliberate choice and excludes any random process. Stratified random sampling is a process where the population embraces a number of distinct categories, the frame is organized into separate strata. Each stratum is then sampled as an independent sub-population, out of which individual elements can be randomly selected. The study employed these three sampling techniques at various levels (Alvi, 2016).

Due to COVID-19 some headmasters were not willing to allow their schools to participate in the study. The researcher selected two schools conveniently from seven. The first school is a GES Category B school and second is a category C school. The selection of these schools from these categories enabled a good

representation of all attributes of data. The researcher randomly selected one school (School A) as the control school and other (School B) as the experimental school. The schools are about seventeen kilometres apart. This helped to lessen the errors that may occur from collaboration and interchange of ideas amongst students from the two groups. This further eliminated the possibility of a John Henry Effect (Frey, 2018). Effect of John Henry is a treatment of unfairness presented to social treatment by reactive behaviour of the control group.

Furthermore, programmes that do not offer elective mathematics were purposively sampled for the study. So that extraneous variables do not reduce the internal validity of the outcomes of the study. Hence, the influence of elective mathematics on the result was reduced. Four intact second year classes were sampled randomly using stratified random sampling procedure from fourteen classes. Two out of eight classes were sampled from Stratum (school) A for the control group and two out of six classes sampled from Stratum (school) B as the experimental group. Table 2 shows the distribution of random numbers in school A and school B.

Table 2: **Distribution of random numbers in school A and school B.**

	Stratum (School) A		Stratum (School) B	
Class	*N*	Random No.	*N*	Random No.
Business 2A	21	A1	-	-
Home Econs 2A	40	A2	38	B1
Home Econs 2B	42	A3	45	B2
Geography 2B	44	A4	-	-
Language 2A	31	A5	48	B3
Language 2B	38	A6	41	B4
Visual Art 2A	32	A7	37	B5
Visual Art 2B	28	A8	34	B6
Total	276		243	

Source: Fieldwork (2020)

In the stratum A (school A), the researcher wrote random numbers from one to eight on pieces of paper, with each number corresponding to a name of a class (see Table 2). The researcher mixed the numbers up and asked a colleague to randomly pick two numbers, one after the other without replacement. The first pick was A6, corresponding to Language 2B and the second was A3, representing Home Economics 2B. These two classes represented the control group.

The same procedure was followed in Stratum B (school B). In stratum B, random numbers B2 (Home Economics 2B) and B5 (Visual Art 2A) were selected. These two classes represented the experimental group (see Table2).

One hundred and sixty-two (162) senior high school form two students were involved in the study. This consists of eighty-two (82) students for the experimental

group and eighty students for the control group. Fifty-two students were males and one hundred and ten (110) were female students (see Table 4)

Data Collection Instruments

To determine the influence of the independent variables (inductive teaching method) on the dependent variable (achievement tests), data was obtained through the use of pre – test, and post – test.

WASSCE Core Mathematics past questions on circle theorem were adapted with little changes to the names and sizes of the angles by the researcher in designing the achievement tests. The items were adapted based on the two profile dimensions that have been stated for teaching, learning and evaluation at the senior high school level, recalling and understanding (30%) and applying knowledge (70%) (Ministry of Education, 2010).

Knowledge is merely the capability or ability to remember materials previously learned. It is the lowest level of cognitive development. Understanding is mainly the ability to grasp the significance of some material that may be oral, pictographic, or figurative. The application of knowledge as a process, includes the aptitude to: apply rubrics, philosophies, approaches, concepts—to tangible states that are novel. The application also includes the ability to produce, solve, operate, plan, demonstrate, discover, implement, carry out, use, etc.

A test blueprint was developed using the test items on circle theorem topics in the Teaching Syllabus for Core Mathematics for Senior High Schools (Ministry of Education, 2010). Specifically, topics covered include Circle Theorems, Tangent

and Radius of a Circle, and Angle between Tangent and a Chord. Table 3 shows the table specification.

Table 3: **Table of Specification**

	Profile Dimensions		
Subtopic	Knowledge	Application	Total
Central angle	-	1	1
Same-segment angles	1	-	1
Semi-circle angle	-	1	1
Cyclic quadrilaterals	1	-	1
Exterior & interior angles	-	2	2
Tangent and radius	1	1	2
Alternate segments	-	2	2
Total	**3**	**7**	**10**

Source: Field work (2020)

Pre-Test

The pre-test consists of ten multiple-choice questions (with a key and three distractors) and two constructed response type questions (see Appendix C). The pre-test was administered in order to determine whether students have equivalent knowledge in plane geometry before the intervention activities. The pre-test was administered on the two groups, six days prior to the start of the intervention activity. The pre-test lasted for a maximum of one hour and scored out of twenty marks. Each student was given a printed question paper.

Post-Test

The post-test was a parallel test to the pre-test. It consists of ten multiple-choice (with a key and three distractors) and two constructed response type questions (see Appendix D). This test was administered to students, a day after the end of the treatment as post-intervention test to determine the success of the treatment. The post-test was also administered for a duration of one hour and scored out of twenty marks.

Like the pre-test, each student was given a printed question paper. Answers of students to the pre-test and post-test questions were marked using a marking scheme prepared by the researcher (see Appendix E and F). Answers to the ten multiple choice test items for each test were scored '1' for correct responses and '0' for incorrect responses. The two constructed response type questions were each scored out of five making a total of 10 marks for each test.

Validity and reliability of the instrument

According to Mohajan (2017, p.14), "validity refers to the extent to which an instrument measures what it intends to measure". Validity addresses the accuracy of the research instrument in terms of measurement. "A researcher's data are valid to the extent that the results of the measurement process are accurate" (Anastasi & Urbina, 2007).

The phenomenon of interest in this study is to examine the effect of inductive teaching approach and its effect on senior high school students' performance in geometry. To ensure that the highest rate of validity was obtained, WASSCE Core

Mathematics past questions were adapted for the two achievement tests. Inputs made by two qualified mathematics educators who were WAEC Core Mathematics assistant examiners before the instruments were sent to a senior lecturer (research principal supervisor) in the Department of Mathematics and ICT Education, to review the content, construct validity and standard of the items with respect to the learners level. The opinions about instruments' strength of measuring the trait to be measured and suggestions (Anastasi & Urbina, 2007) were adhered to.

The Teaching Syllabus for Senior High Schools Core Mathematics also aided the determination of curricular validity by examining the content of the test and judging the degree to which it is a true measure of the specific objectives of the study. Also, lesson plans were written and vetted by the research supervisor and the necessary amendments were made.

Reliability refers to the "extent to which a measuring instrument yields the same results on repeated applications" (Anastasi & Urbina, 2007 p.12). It means the degree of dependability of a measuring instrument. The reliability of the test was checked by KR-20 and Cronbach's alpha estimates. These procedures were used to regulate the internal consistency of the items on the test. A reliability coefficient of .805 was achieved for multiple choice questions and an estimate of .732 was achieved for the essay using Cronbach's alpha. Gay, Mills, and Airasian, (2011) suggested that, a test is a good measure if its reliability coefficient surpasses 0.60. The value indicated a good degree of reliability of the instrument. The result also suggests that the test items, to some extent, were free from errors.

Pilot Testing of Instruments

Participants for the pre-testing activity were second year students of Wheta Senior High School, a nearby school in the study area. The reason for the choice of this school had to do with the similarity in attributes and characteristics with the students in the study area. There were thirty-eight (38), consisting of twenty-one (21) females and seventeen (17) males for the piloting. The tests were administered in addition to a blank sheet for comments on the intelligibility, weakness and ambiguity of the instruments. Out of such comments, statements that were indistinct, misleading and /or repeated were revised, deleted, re-constructed or broken down into simpler forms. For example, the numbering order of some of the items also changed since some were considered as follow-up questions to the ones before them.

The pilot exercise proved very useful since it helped to streamline and reduce the number of items. More importantly, it helped to improve the quality of the instrument for the study. The pilot exercise was conducted from 18th - 20th February, 2020.

Data Collection Procedure

The researcher sought authorisation from the Institutional Review Board (IRB) of the University of Cape Coast to implement the research (see Appendix I). After the approval was given by IRB, a permission letter was sent to Heads of selected schools one week prior to the data collection exercise (see Appendix J). Preceding the start of the data gathering, the researcher went to the selected schools to explain the reasons for the study. In addition, the researcher had a conversation with

mathematics teachers of the sampled classes and sought for their support towards administration and invigilation of the students in the tests. Students were assigned participant numbers, which were used for all the tests. Four days prior to teaching, the researcher conducted pre – test for students in the two groups in order to determine whether students have equivalent previous knowledge in plane geometry.

The experiment on the inductive teaching method

The treatment took a period of two weeks. There were three lessons—two lessons in the first week and one lesson in the second week. A lesson lasted for two hours. The researcher taught the experimental and the control group. To check students' attendance regularly the researcher prepared attendance register for each group. The treatment activity was done from 12th - 22nd October, 2020.

The experimental group was taught geometry using inductive method whereas the control was taught geometry using conventional teaching approach. However, all other conditions remain the same for the two groups—topics to be taught were the same for the two groups.

The inductive teaching process for example follows this order; the teacher engages students in a practical activities. For example, teacher asks students to draw at least three circles using different radii in a group of three members. For each circle, draw a chord. Using the chord, create angles at the centre and the circumference. Teacher then, guided the students to identify the relationship between the angles. Teacher then, posed questions involving angle subtended at

the centre and that at the circumference by an arc (the theorem) and assisted students to solve relevant problems until they recognise relationship between angle subtended at the centre and that at the circumference by an arc (details are in Appendices A and B).

Lesson one was on the subtopics: Circle Theorem 1 (Central Angle Theorem), Circle Theorem 2 (Angles in the Same Segment) and Circle Theorem 3 (Angles in a Semi Circle). Students were asked to recall parts of a circle; centre, radius, diameter, circumference, chord, sector, segment, and arc to introduce the lesson after which the lesson for day was taught.

The second lesson focused on the Circle Theorem 4 (Cyclic Quadrilateral and the exterior angle, and opposite interior angle in a cyclic quadrilateral.

The third lesson focused on the relation between tangent and radius of a circle. Two theorems learned in this are the tangent and radius of a circle theorem and alternate angle theorem. Details of the teaching process are in Appendices A and B.

The teaching process was followed by a post-test for the experimental and control groups. The post-test also lasted for 60 minutes and was scored out of twenty marks.

COVID-19 Safety and Health protocols

To prevent the spread of Coronavirus Disease 2019 (COVID-19), students were required to wear face covering while in the classroom for the intervention process. Students were asked to stay at least 2 metres from others at all times. Frequent hand washing was one of the most important actions that were encouraged after touching

anything in the study area. Regular hand washing was done with soap and under running water. Hand sanitizer with at least 70% alcohol was provided. Temperatures of students were checked daily (Ghana Health Service, 2020)

Data Processing and Analysis

The purpose of data analysis in research is to present data gathered in the study in a well-organized and meaningful way in order to answer research questions and hypotheses.

Results are presented in tables indicating descriptive statistics such as means, standard deviations and percentages. The pre-test score of the two groups were analysed by computing the mean scores and standard deviation. The descriptive statistics were compared to check if the scores differ markedly. To establish whether the observed difference was statistically significant, the independent sample t-test was run on the raw scores of students. This revealed a significant difference in the performance of students before the intervention or the treatment. In view of that, there was the need to control for the 'effect' of the pre-test scores since it can give misleading results (Adam, 2015). Therefore, Analysis of Covariance (ANCOVA) was used to test the hypothesis one, of effect of treatment on achievement. This was to adjust the post-test scores based on their initial difference on the pre-test scores and control the 'effect' of the pre-test scores on the post-test. However, there was no statistically significant difference in the performance of male and female students in experimental group before the treatment hence, the research hypothesis two was tested using independent sample t-test.

The data were analysed with the aid of Statistical Package for the Social Sciences (SPSS) version 23. Before the analyses of the data were done, the researcher did preliminary data screening. This involved checking for missing values, checking for assumptions of outliers and normality. The data entries were done by the researcher in order to check the accuracy of the data. Data cleaning was done and this helped to get rid of errors that could result from coding, recording, missing information, influential cases or outliers".

Data analysis for research question one

To answer research question one, "*what is the effect of the inductive teaching method on students' achievement in circle theorems test?"* achievement post-test scores of students taught circle theorems using inductive teaching method were compared to achievement post-test scores of students taught circle theorems using conventional teaching method using tables indicating descriptive statistics such as frequencies, percentages, mean and standard deviation. The descriptive statistics were compared to check if the scores differ markedly (details in Tables 5 and 6).

Data analysis for research hypothesis one

To test research hypothesis one, "*There is no significant difference in the mean achievement scores of students taught plane geometry using the inductive method and those taught the same plane geometry using traditional method of teaching*" group means were compared using independent samples t-test after normality was assumed (Normal Q-Q Plot was used, see Figure 2 and Figure 3) and the homogeneity of variance assumption was checked using Levene's test (details in

Figure 4). The study used intact classes. Therefore, initial equivalence was not achieved for the research subjects in the two groups (details in Table 7). To determine the effect, the post-test scores for respondents in the experimental and control groups were compared, while controlling for the influence of the pre-test scores (Gordor & Howard, 2006) using one-way ANCOVA at a significant level of 0.05 (details in Tables 8 and 9). The dependent variable was post-test scores, the independent variable was the teaching methods for the groups (control and experimental) using pre-test scores as the covariate.

Data analysis for research question two

To answer research question two, "*What is the difference in the performance of male and female students taught circle theorems using inductive teaching method?"* achievement post-test scores of students who were taught circle theorem using inductive teaching method were compared based on gender using tables indicating descriptive statistics such as frequencies, percentages, mean and standard deviation. The descriptive statistics were compared to check if the scores differ markedly (details in Tables 10 and 11).

Data analysis for research hypothesis two

The hypothesis is "*There is no significant difference in the mean achievement scores of male and female students taught plane geometry using the inductive approach".*

Independent sample t-test at a significant level of 0.05 was used to test hypothesis two which determine means scores and standard deviations of male and female students in the experimental group only (details in Table 13).

Data management

The responded research instruments of participants was marked and entered in the SPSS software for data analysis. The marked instrument of each participant was stored in the researcher's locker accessible to him. The softcopy of the scores entered in SPSS software was saved into the researcher's Dropbox account before, during and after data analysis. These was done to prevent third parties from having access to the responded instrument for confidentiality sake.

Ethical clearance by the University

The researcher sought for a research authorization letter from the University of Cape Coast, Institutional Review Board (UCCIRB) (see Appendix I). The UCCIRB reviewed and approved the research and an ethical clearance certificate was issued on the 28th August, 2020. The approval was granted by UCCIRB (see Appendix J) and Ministry of Education in Ghana through the municipal director before embarking on data collection process as dictated by ethics.

Informed consent is the approval granted (in full understanding of the possible consequences) by a participant to a researcher for treatment with knowledge of the possible risks and benefits. A permission letter was sent to all the sampled schools. The permission letter explained the reason of the study and requested them to permit students to partake in the study. The permission letter was sent a week prior

to the data collection exercise to enable participants to be aware of what they will be requested to do, and the benefits. The purpose of the research, the procedure as well as accompanying demands and possible benefits were explained to the respondents for them to get a clear understanding of the study.

Minimising the risk of harm

This study followed standard scholastic study processes, hereafter the research was unlikely to cause mischief or pain to students. The research doesnot affect the usual teaching and learning periods for SHS2. The study was carried out during the core mathematics periods on the schools' teaching and learning schedules.

Anonymity and Confidentiality

Anonymity and confidentiality were upheld throughout data collection process for the study. Data gathered were stored safely and treated confidentially at all phases of the research process. To ensure a high response rate of the items on the instrument administered as well as confidentiality, the identity of respondents who partook in the research were not recorded on the instrument. In this research, the ethical moralities were followed—to consider the likely significances of gathering and disseminating various types of data and protect against likely misinterpretations. The researcher (i) did not inflate the correctness or explanatory power of the data; (ii) presented results and interpretations fairly and accurately; (iv) avoided false, or misleading statements; (v) gathered only data required for the purpose of the study; (vi) took steps to correct or refine the data—applied statistical processes to the data.

Chapter Summary

The research tried to examine the effect of inductive teaching method on senior high school students' achievement in circle theorems. The chapter presented the design, study area, population, sampling procedures, data collection procedure and instruments, data analysis procedure and ethical issues.

Quasi-experimental method, non-equivalent control group design was employed. The study was done in Keta Municipality, Volta Region of Ghana in two different schools. Stratified random sampling was used in selecting the two intact classes within each school for the study. The respondents were not randomly allocated to groups. Four intact classes were used and assigned to two groups. The experimental group learnt through the inductive teaching method. The control group, on the other hand, received tuition through the use of the conventional approach of teaching, which was more of deductive approach. Samples of 82 and 80 participants were used as treatment and control groups respectively. Two main data collection instruments used were pre-test and post-test. A pre-test was given to check whether the two groups were similar in geometry ability before treatment. Data gathered was quantitatively analysed in order to establish whether there is any statistically significant differences between the two groups after the treatment. The data collection process conformed to COVID-19 safety and health protocols.

Possible limitations includes; unequal groups were used as control and experimental. This as a result, created possible error in the data analysis due to non-randomization of constituents of the study. The researcher used purposive sampling procedure to select second-year students in senior high schools in Keta Municipal,

therefore, the findings cannot be generalized for all students in senior high schools in Keta as well as Ghana. However, the data generated from this study can serve as basis for quantitative research where large sample size can be used in order to generalise the findings.

Also, the study was focused on plane geometry II (Circle Theorem) of the Senior High School Core Mathematics Curriculum. Therefore, the conclusions of the study were not extended beyond the scope of the study.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

The study sought to determine the effect of the inductive teaching method on senior high school students' achievement in circle theorems and to determine whether students' gender influences their achievement in circle theorems in Keta Municipal.

This chapter presents the analysis of data collected, the interpretation and presentation of the result in two sections; background information of the participants, and the main results. The main results derived from the data analysis are presented under specific subheading according to the research questions and hypotheses. There are two research questions and two research hypotheses.

Background Information of Participants

This segment presents the results on the background information of the participants.

Distribution of Participants by gender

There are two groups of participants—control (students taught circle theorems using conventional instructional approach) and experimental (students taught circle theorems using inductive method) groups. Table 4 presents the distribution of participants based on group and gender.

Table 4: **Distribution of participants by group and gender**

Gender	Control		Experimental		Total	
	F	*%*	*F*	*%*	*N*	*%*
Male	32	40.0	20	24.4	52	32.1
Female	48	60.0	62	75.6	110	67.9
Total	80	100.0	82	100.0	162	100.0

Source: Fieldwork (2020)

From Table 4, there were more female (67.9%) than male (32.1%) participants in the study. There were 48 females and 62 females in the control and the experimental groups respectively. The males were 32 for control group and 20 for experimental group.

Main Results

This section presents the results in line with the research questions and hypotheses. The students' answers to the ten multiple-choice test items in the pre-test as well as the post-test were marked using a marking scheme and scored on the basis of '1' for correct response and '0' for incorrect response. The two constructed response type questions were scored out of ten, each carrying five marks (details in Appendices E and F).

Research question one

To answer research question one, "*what is the effect of the inductive teaching method on students' achievement in circle theorems test?"* the achievement post-test scores of students taught circle theorems using inductive teaching method were compared to the achievement post-test scores of students taught circle theorems

conventionally. Descriptive statistics such as frequencies, percentages, mean and standard deviation were used for this analysis. The descriptive statistics were compared to check if the scores differ markedly.

In order to gain a better insight into the analysis of the effect of inductive teaching approach, the pre-test scores were analysed to precede that of the post test. The pre-test items were based on basic geometric concepts identified as pre-requisites to the learning of circle theorems. Table 5 presents the grouped frequency distribution of scores obtained on the pre-test of students in the experimental and control groups.

Table 5: **Distribution of pre-test scores of students**

Scores (out of 20)	Control Group			Experimental Group		
	F	%		*F*	%	
0 – 2	11	13.75		21	25.61	
3 – 4	25	31.25		31	37.80	
5 – 6	22	27.50		20	24.39	
7 – 8	12	15.00		5	6.10	
9 – 10	3	3.75		2	2.44	
11 – 12	6	7.50	8.75	2	2.44	3.66
13 – 14	1	1.25		1	1.22	
	7			3		
Total	80	100		82	100	

Source: Fieldwork (2020)

From Table 5, majority of the students in both groups performed below the average score of 10 marks in the pre-test. Only seven out of 80 students from the control group had scores more than 10 out 20 representing 8.75% while only three out 82 students from the experimental group had scores more than 10 out 20

representing 3.66% (see Appendix G for the raw scores). The minimum score is zero and the maximum score is twenty (20)

The mean scores and standard deviations were then computed. The computation revealed that, the control group had a higher mean score of 5.338 (with standard deviation of 2.783) than the experimental group (M = 4.12, with SD = 2.49), (see Table 7) before the treatment. The implication of this result is that the groups were not the same in terms of students' achievement in basic circle theorems before the treatment.

The treatment process was followed by a post-test for the experimental and control groups. Table 6 presents the distribution of post-test scores of students in the experimental and control groups.

Table 6: **Distribution of post-test scores of students**

Scores (out of 20)	Control group			Experimental Group		
	F	%		*F*	%	
3 – 4	1	1.25		0	0.00	
5 – 6	2	2.50		0	0.00	
7 – 8	4	5.00		6	7.32	
9 – 10	9	11.25		2	2.44	
11 – 12	13	16.25		5	6.10	
13 – 14	13	16.25		8	9.76	
15 – 16	14	17.50	80.0	14	17.07	90.2
17 – 18	17	21.25		15	18.29	
19 – 20	7	8.75		32	39.02	
Total	80	100		82	100	

64 (Control group) | 74 (Experimental Group)

Source: Fieldwork (2020)

From Table 6, it is clear students in the experimental group had better scores as compared to students in the control group. As many as 74 (90%) students in the

experimental group had scores more than 10 out of 20 while 64 (80%) of students in the control group had scores in the same range.

Comparing this result from Table 6 with the pre-test scores shown in Table 5, it can be seen that majority of the students had performed higher in the post test than they did in the pre-test (see Appendix G for the raw scores). The performance of students has improved by 71.25% (from 8.75% to 80%) for the control group and 86.5% (from 3.66% to 90%) for the experimental group. It revealed that, students who were taught circle theorems using inductive teaching method has improved more than students who were taught circle theorems conventionally.

The mean scores and standard deviations were then computed. The computation revealed that, students who were taught circle theorems using inductive teaching method had a higher post-test mean score (M = 16.34, with SD = 3.73), than students taught circle theorems conventionally. (M = 13.61, with SD = 3.89), (see Table 9). One possible implication is that, the inductive method is effective in enhancing students' performance in circle theorems. To establish the significance of the observed difference in performance, the following hypothesis was raised and tested.

Research hypothesis One

H_{O1}: There is no significant difference in the mean achievement scores of students taught circle theorems using inductive method and those taught using conventional instructional approach.

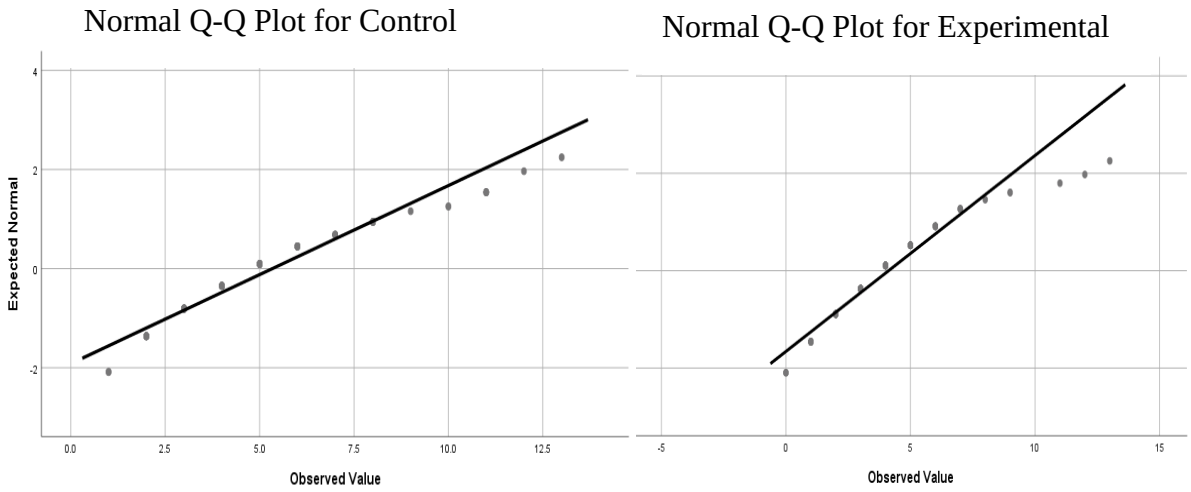
The research hypothesis sought to find out if there are differences in the the mean achievement scores of students taught circle theorems using inductive method and those taught using conventional instructional approach. The post-test scores for respondents in the experimental (students taught circle theorems using inductive method) and

control (students taught circle theorems using conventional instructional approach) groups were compared. To control the influence of the pre-test scores the one way ANCOVA was used to do the analysis.

Assumptions and conditions

Prior to the testing of hypothesis one, preliminary analyses were conducted to check assumptions and conditions surrounding the statistical procedures to be used.

First, the normality assumption was checked for the pre-test scores of control and experimental groups. The details are shown in Figure 2.



Source: Fieldwork (2020)

Figure 2: Normal Q-Q plots for pre-test data

As depicted in Figure 2, the distribution for the pre-test data was normal since all the plots were approximately fit onto the straight line in each case.

Having normality of the distribution for pre-test data established, parametric statistical procedures were triggered for testing of the hypotheses upon satisfying

homogeneity of variance assumptions and conditions relative to those procedures (Adam, 2015).

The pre-test scores of the two groups were also compared using independent samples t-test. Having assumed normality, the homogeneity of variance assumption was checked using Levene's test, and the result showed no violation of the assumption (p = .175). Table 7 presents the comparison of pre-test scores for the groups using independent samples t-test.

Table 7: **The t-test statistics for comparing pre-test scores of control and experimental groups**

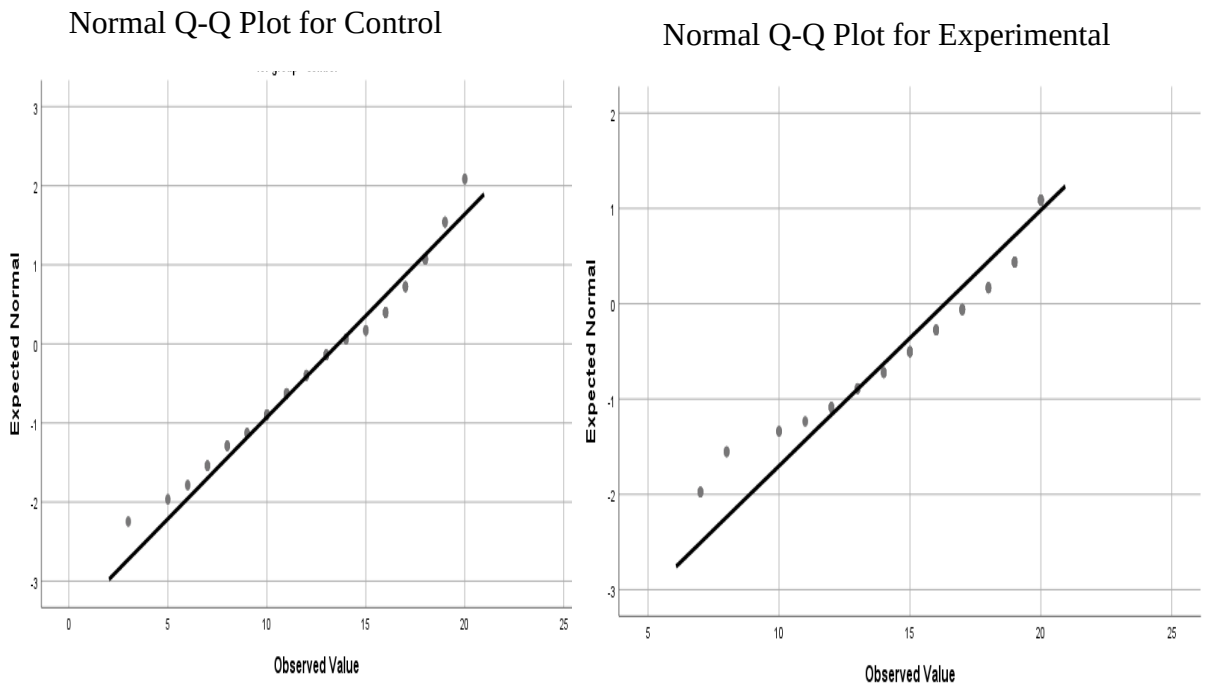
Group	*N*	*M*	*SD*	*t*	df	*p*
Control	80	5.338	2.783	2.933	160	.004*
Experimental	82	4.122	2.486			

Source: Fieldwork (2020) **Significant, p < .05*

The results of the independent samples t-test in Table 7 showed a statistically significant difference between the pre-test scores for participants in the control group (M = 5.34, SD = 2.78) and those in the experimental group (M = 4.12, SD = 2.49), $t(160) = 2.933$, p = .004. The implication of this result is that the groups were not the same in terms of students' achievement in basic geometric concepts before the treatment.

In view of that, there was the need to control for the 'effect' of the pre-test scores since it can give misleading results (Adam, 2015). Hence, Analysis of Covariance (ANCOVA) was used to test hypothesis one, since this will adjust the post-test scores based on their initial difference on the pre-test scores.

The normality assumption was also checked for the post-test and the details are shown in Figure 3.

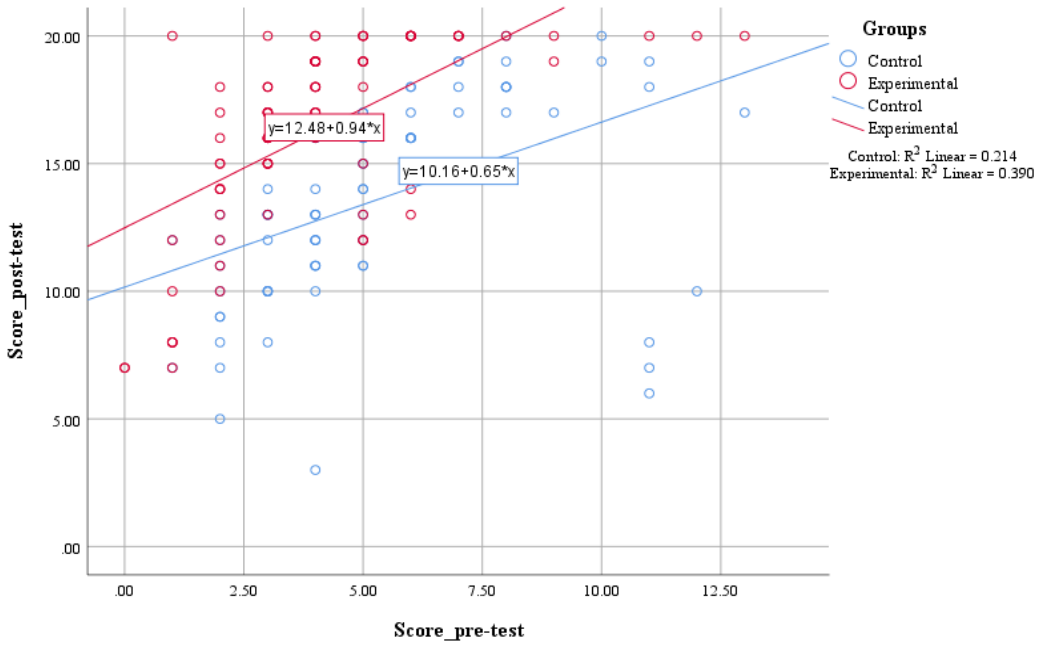


Source: Fieldwork (2020)

Figure 3: Normal Q-Q plots for post-test data

As shown in the figure 3, the post-test data was normally distributed since all the plots were approximately fit onto the straight line.

In order to use ANCOVA, a paramount assumption, homogeneity of regression slopes assumption was also checked (see Figure 4).



Source: Fieldwork (2020)

Figure 4: Homogeneity of regression slopes

As shown in the Figure 4, there was no interaction between the slopes for the control and experimental groups. Scores of students taught circle theorems using inductive method and those taught using conventional instructional approach were similar. This implies that, the association between the pre-test scores and the post-test scores was similar for both the control and the experimental groups, hence no violation of the assumption.

The Analysis of Covariance (ANCOVA) test was then carried out. The independent variable had two levels: control and experimental groups. The dependent variable was the post-test scores (the homogeneity of variance assumption was checked using Levene's test, and the result showed no violation of

the assumption, $p = .651$). The pre-test score was used as the covariate in the model. Table 8 shows the summary statistics of the ANCOVA test.

Table 8: **ANCOVA test for differences in post-test scores**

Source	*df*	*MS*	*F*	*p*	*Eta*^{2}
Corrected Model	2	486.274	46.846	<.001	.371
Intercept	1	4862.552	468.447	<.001	.747
Pre-test	1	670.981	64.641	<.001	.289
Group	1	518.395	49.941	<.001*	.239
Error	159	10.380			
Total	162				
Corrected Total	161				

Source: Fieldwork (2020) **Significant, p < .05*

The results in Table 8 show that, while controlling for effects of the pre-test, there was a statistically significant difference in the post-test scores of the control group(students taught circle theorems using conventional instructional approach) and experimental group(students taught circle theorems using inductive method), $F(1, 159) = 49.94$, $p < .001$, partial eta squared = .239. From the results, it can be said that, practically, the groups accounted for 23.9% of the variations in students' achievement scores in circle theorems. This effect was considered large. Testing for the differences was done using the adjusted post-test means for the groups from ANCOVA results, while controlling for the influence of the pre-test scores. Table 9 shows the adjusted post-test mean scores for the groups.

Table 9**: Adjusted and unadjusted group means**

		Unadjusted		*Adjusted*	
Group	*N*	*M*	*SD*	*M*	*SE*
Control	80	13.613	3.893	13.135	.365
Experimental	82	16.342	3.726	16.808	.360

Source : Fieldwork (2020)

From Table 9, the adjusted post-test mean score for the experimental group (*M* = 16.81, *SE* = .36) was higher than that of the control group (*M* = 13.14, *SE* = .37). Therefore, there is a statistically significant difference between the two groups. Comparatively, it can also be said that the students taught circle theorems using inductive method(experimental group) had performed better than the students taught circle theorems using conventional instructional approach(control group) in circle theorems after the treatment. This therefore implies that, the inductive method was effective in enhancing students' performance in circle theorems.

Comparing performance of male and female students

The post-test scores of students who were taught circle theorems using inductive teaching method were compared based on gender. Tables indicating descriptive statistics such as frequencies, percentages, mean and standard deviation were used for the analysis. The descriptive statistics were compared to check if the scores differ evidently. Table 10 shows the distribution of the pre-test scores of the male and female students in the experimental group.

Table 10: **Distribution of the pre-test scores of experimental group by sex**

Scores	Male		Female	
(20 marks)	*F*	%	*F*	%
0 – 2	4	20.0	17	27.4
3 – 4	8	40.0	23	37.1
5 – 6	5	25.0	16	25.8
7 – 8	1	5.0	3	4.8
9 – 10	1	5.0	1	1.6
11 – 12	1	5.0	2	3.3
Total	20	100	62	100

Source: Fieldwork (2020)

From Table 10, majority of the students in both groups performed below the average score of 10 in the pre-test. Only one out of 20 male students had a score more than 10 out 20 representing 5% while only two out of 62 female students had scores more than 10 out 20 representing 3%. The mean scores and standard deviations were then computed. The computation revealed that, male students had a higher mean score (M = 4.75, SD = 2.92) than their female counterparts (M = 3.92, SD = 2.32), (see Table 12).

Observation was also made on post-test scores of male and female students in the experimental group. Table shows 11 the distribution of the post-test scores of the male and female students in the experimental group.

Table 11: **Distribution of the post-test scores of experimental group by sex**

	Male			Female		
Scores	*F*	%		*F*	%	
7 – 8	1	5.0		4	6.5	
9 – 10	0	0.0		3	4.8	
11 – 12	0	0		5	8.1	
13 – 14	1	5.0		7	11.3	
15 – 16	3	15.0	95.0	11	17.7	85.9
17 – 18	4	20.0		11	17.7	
19 – 20	11	55.0		21	33.9	
Total	20	100		62	100	

Source: Fieldwork (2020)

From Table 11, it is clear that male students had slightly better scores as compared to female students. As many as 19 (95%) male students had scores more than 10 out of 20 while 55 (86%) of female students had scores in the same range.

The mean scores and standard deviations were then computed. The computation revealed that, male students had a higher post-test mean score (M = 17.75, with SD = 3.23), than female students (M = 15.89, with SD = 3.79), (see Table 13). There was therefore the need to test the significance of the difference between the post-test scores of male and female students.

Research hypothesis two

H_{O2}: *There is no significant difference in the mean achievement scores of male and female students taught circle theorems using the inductive instructional approach.*

The research hypothesis two examined whether the inductive method discriminates between male and female students in terms of their performance in geometry. This hypothesis sought to find out if there are differences in the mean achievement scores of male and female students taught geometry using inductive method.

Assumptions and conditions

Prior to the testing of the hypothesis two, preliminary analyses were conducted to check assumptions and conditions surrounding the statistical procedures to be used.

First, the normality assumption was checked for the pre-test scores for experimental group. The details are shown in Figure 2.

The pre-test scores of the experimental group having assumed normality, the homogeneity of variance assumption was checked using Levene's test, and the result showed no violation of the assumption (p = .259). Therefore, there was the need to test the significant of the difference between pre-test scores using independent sample t-test. Table 12 presents the results on the independent samples t-test.

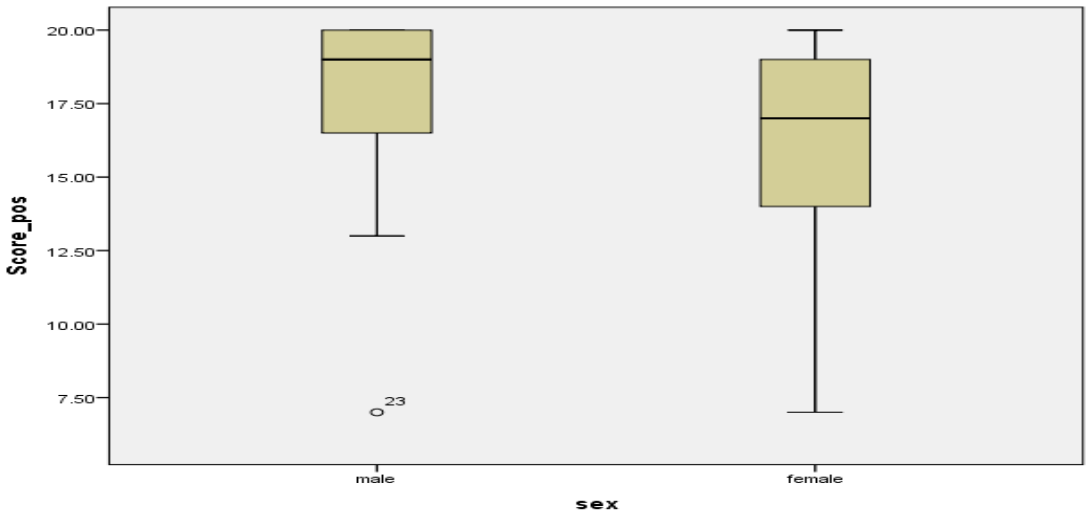
Table 12: **The t-test value for pre-test scores of experimental group by sex**

Gender	*M*	*SD*	*t*	*df*	*p*
Male	4.750	2.918	1.305	80	.196
Female	3.919	2.321			

Source: Fieldwork (2020)

From Table 12, there was no statistically significant difference between the pre-test scores for both male participants (M = 4.75, SD = 2.92) and female participants (M = 3.92, SD = 2.32); $t(80) = 1.305$, $p = .196$ in the experimental group. The implication is that sex of a student did not influence their achievement in circle theorems before the treatment. Therefore, independent sample t-test was used to test the hypothesis two since there was no need to control the 'effect' of the pre-test scores (Adam, 2015).

Using post–test distribution of experimental group was later checked using normal box plot. Figure 5 showed that the distribution for the post-test data of experimental group based on gender was normally distributed since all the plots were approximately equal.



Source: Fieldwork (2020)

Figure 5: Normal box plots for post-test data for gender

Having assumed normality for the post test scores, the homogeneity of variance assumption was checked using Levene's test, and the result showed no violation of assumption (p = .131). Using independent sample t-test, the independent variable was gender, which had two levels: male and female. The dependent variable was the post-test scores of the experimental group. Table 13 shows summary statistics of the independent sample t-test.

Table 13: **The t-test statistics for comparing post test scores of experimental group.**

Group	*M*	*SD*	*t*	*df*	*p*
Male	17.750	3.226	1.979	80	.051
Female	15.887	3.786			

Source: Fieldwork (2020)

From the Table 13, there was marginally no significant difference between the post-test scores for both male participants (M = 17.75, SD = 3.226) and female participants (M = 15.89, SD = 3.79), [$t(80) = 1.979$, p = .051] in the experimental group(students taught circle theorems using inductive method). The implication is that achievement of male and female in circle theorems after the treatment was the same. It can be concluded that there was no statistically significant difference in the performance of male and female students taught geometry using inductive method of teaching.

Discussion of Results

The study was to examine the use of inductive instructional method and its effect on students' achievement in circle theorems and to determine whether such effects

were influenced by gender of students in Senior High Schools in the Keta Municipal. Research questions were answered using descriptive statistics such as frequencies, percentages, mean and standard deviation. Research hypothesis one was addressed using ANCOVA. While Research hypothesis two was addressed using independent sample t-test.

The study established that, learners in both groups exhibited an improvement in the understanding of circle theorems in the post test as compared to the pre-test. Nevertheless, students taught circle theorems through inductive based teaching approach achieved better results compared to those taught with the conventional teaching approach. Statistically there was a significant difference in the post-test scores of the control and experimental groups in favour of the experimental group. This therefore implies that, the inductive method is effective in enhancing students' performance in circle theorems. This finding was consistent with Atta *et al*. (2015) who examined the achievements of basic school pupils in mathematics and established that, pupils who were taught mathematics inductively performed better than the group of pupils who were taught mathematics deductively.

The study also affirmed the argument of Acharya (2016) and Ihedioha and Osu (2012) on exploration of efficiency of inductive analysis and transmitter of knowledge models on senior high school students' academic performance on circle theorem and trigonometry that inductive technique of teaching geometry had superior achievement than that of the deductive method of teaching.

However, the finding contradicts Rahmah (2017), who conducted an experimental quantitative study that emphasized on improving mathematical

concept and problem-solving for Junior High School (JHS) pupils by inductive teaching. The result has shown that, learning mathematics by using inductive method could not increase pupils' mathematical problem-solving ability significantly compared to traditional teaching.

The computation of the mean and standard deviation values revealed that, male students had a higher post-test mean score than female students. However, a further test to see whether male students performed significantly different from their female counterparts after receiving instruction in circle theorems through the use of the inductive teaching method revealed no significant different in the post-test scores of participant. Males had performed same as females after being taught circle theorems using inductive method of teaching. This confirms the finding was the opinion that gender has no specific effect on the learning of mathematics (Tetteh Korkor *et al.* (2018), Arhin and Offoe 2015 and Yarkwah, Arthur, and Donkor 2020). The finding also supports the claim by Mullis, Martin, Foy, and Hooper (2016) in an international assessment aimed at helping countries to make decisions about how to improve instruction in science and mathematics education conducted by TIMSS in 2015 for eight grade students' mathematics achievement of 39 participating nations revealed that there was no difference in performance of boys and girls in 26 participating countries. Furthermore, the study was consistent with the finding of Adegun and Adegun (2013) on the impact of gender on students' perceived levels of difficulty of mathematics topics in the secondary school mathematics curriculum that there was no difference in the performance of boys and girls in geometry.

In contrast with the finding was Mutai (2016) who argued that gender has effect on learning of mathematics in favour of males. This was as a result of the stronger affinity and interest male students have towards the learning of mathematics. Mutai re-emphasized that, learning geometry is believed to be determined by gender differences.

Summary of Key Findings

The study aimed at determining the efficacy of the use of the inductive instructional method of teaching geometry on students' achievement and the extent to which such effect was influenced by gender of SHS students in the Keta Municipal. The study revealed that learners who were taught circle theorems inductively had performed significantly better than learners who learned circle theorems by conventional approach. This implies that, the inductive method is effective in enhancing students' performance in circle theorems.

Students' gender had no effect on their achievements in circle theorems. Male students had performed similar as the female students on circle theorems test after experiencing tuition via inductive teaching method. This is a revelation that male and female students are capable of competing and collaborating in learning circle theorems especially, in circle theorems classroom activities using inductive teaching method.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a summary of the study, conclusions from the study and recommendations for possible application. The chapter ends with suggested areas worthy of further study. The research aimed at determining the efficacy of using inductive instructional method and its effect on students' achievement in circle theorems. The study also investigated whether the effects were affected by gender of students in the Keta Municipal. The study was guided by two research questions and two null hypotheses.

Summary

The aim of study was to examine the effect of using inductive teaching method on senior school students' achievement in circle theorems.

The quasi-experimental (Pre-test-Post-test) non-equivalent control group design was employed. The test scores were analysed using descriptive statistics such as frequencies, percentages, mean and standard deviation. The ANCOVA and independent sample t-test were used to test the significance of observed differences in the groups and gender. One hundred and six-two SHS2 students in the Keta Municipal were selected for study. Convenience, purposive and stratified random sampling procedures were used to select study area, two schools and four classes for the study. Eighty-two (82) students formed the experimental group and eighty (80) students formed the control group.

There was a treatment which took a period of two weeks. There were three lessons—two lessons in the first week and one lesson in the second week. The

experimental group was taught geometry using inductive method whereas the control group was taught circle theorems using conventional teaching approach. The topics taught were the same for the two groups.

Data was obtained through the use of pre – test, and post – test. The pre-test was administered prior to start of the treatment and post-test was administered at the end of the treatment. The reliability of the study was estimated using KR-20 and Cronbach's Alpha to check internal consistency and validity of the study.

With the help of the Statistical Package for the Social Sciences (SPSS), data gathered were analysed using both descriptive statistics such as percentages, frequencies, means, standard deviations, and inferential statistical methods such as independent t-test, and Analysis of Covariance, according to the requirement of the specific research questions and null hypotheses. Frequency tables were used to display distribution of pre-test scores of the control and experimental groups. Normal Q-Q Plot was used to check the Normality assumptions for the pre-test and post-test. The pre-test scores of the control and experimental groups were subjected to independent samples t-test. To determine the "effect" of treatment, the post-test scores for participants in the experimental and control groups were compared, while controlling for the influence of the pre-test scores using ANCOVA. The null hypothesis two was tested using independent samples t-test.

The study revealed that, those who were taught circle theorems using inductive approach performed higher than those who were taught circle theorems conventionally. This is an indication that, the inductive method was effective in enhancing students' performance in circle theorems. This confirms the efficacy of

the use of inductive instructional method and its positive effect on senior high school students' achievement in circle theorems.

The study also revealed that there was no difference in the performance of boys and girls taught circle theorems using inductive method of teaching. Male students had performed equally as the female students on circle theorems achievement test after experiencing tuition via inductive teaching method. This implies that students' gender had no effect on their achievement in circle theorems, thereby revealing that male and female students are capable of competing and collaborating in mathematics.

Conclusions

The following conclusions were made based on the results of analysis.

The inductive method of teaching has the potential to assist students to overcome the fear that interferes with their performance in circle theorems. It was thus concluded that, teaching circle theorems using inductive approach enhances students' performance since the inductive method was seen to be effective in enhancing students' performance in circle theorems.

Finally, it is concluded that, sex had an insignificant effect on senior high school students' achievement in circle theorems based on the result that both sexes were capable of competing and collaborating in classroom mathematics activities.

Recommendations

Based on the main findings the investigator made the following recommendations:

1. Mathematics teachers should vary their classroom teaching practices, including inductive teaching method in mathematics. This is because the use of the inductive teaching approach enhances SHS2 students' performance in circle theorems.
2. Mathematics teachers are enjoined to use inductive teaching method as an instructional approach to foster greater healthy rivalry teaching and learning circle theorems in male and female students

Contribution of the Thesis to Knowledge

This research has contributed to knowledge in many ways. In the first place, this research has expanded and strengthened the inductive instructional method to teach circle theorems. As a result, this thesis adds significantly to the existing literature.

The study also expands and strengthens the fact that the use of inductive instructional method aids learning activities of the learner. This means that the teaching process appeals the attention of the learners, improves long term memory thereby enhances recall.

Suggestions for Further Research

Based on the findings the researcher suggested the following areas for further study;

1. The study should be replicated in other regions in the country to find out what happens there. Future studies may incorporate the use of qualitative instruments to make the study more interactive and to get an in-depth understanding of the problem.

2. The study was conducted at the senior high school level; further studies can be done at the basic school level and colleges of education level.
3. Further research would need to be undertaken to examine the trends that emerged in this study in greater depth. A sounder approach would be to examine situational factors that may be influencing gender differences, for example, classroom cultures, teacher attitudes, parental and teacher attitudes and others.

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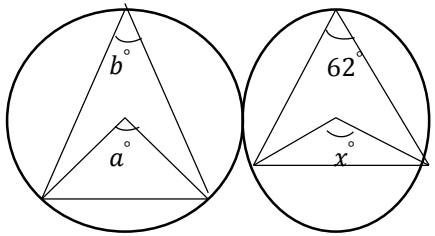
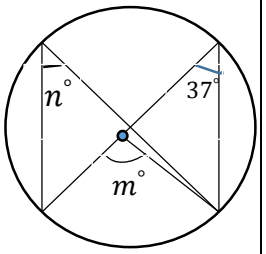
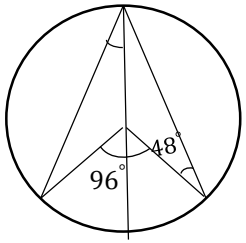
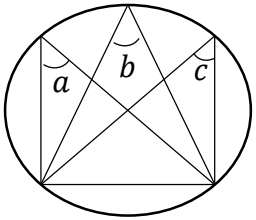
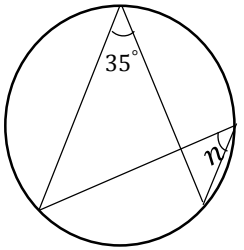
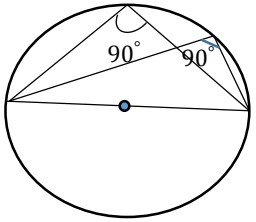
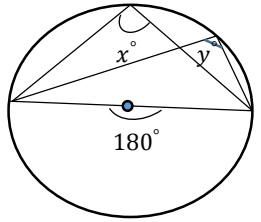
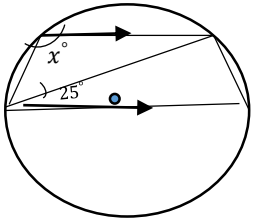
APPENDICES

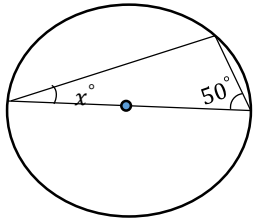
APPENDIX A

LESSON PLAN FOR THE CONTROL GROUP

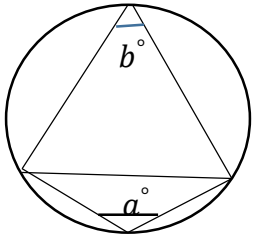
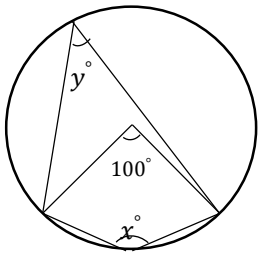
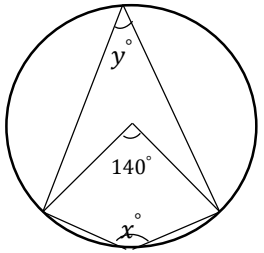
Control group lesson one

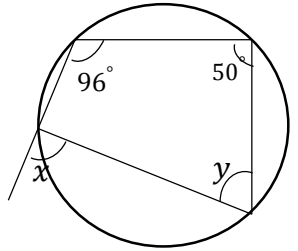
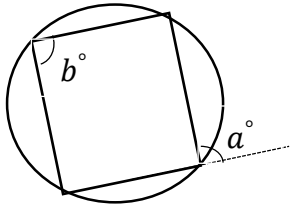
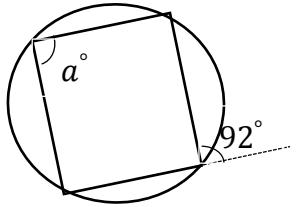
DATE	SUBTOPIC	OBJECTIVES/ RPK	ACTIVITIES	CORE POINTS	EVALUATION
Tuesday 13/10/20 8:00am – 10:00 am	Centre and circumference theorem	R.P.K. Students can identify parts of a circle OBJECTIVES By the end of the lesson, the student will be able to; 1.state the relationship between angle subtended at the centre and that at the circumference by an arc	INTRODUCTION Assist students to recall parts of a circle PRESENTATION Give rule and guide students to use it to solve examples involving angle subtended at the centre and that at the circumference by an arc.	Parts of circle are; centre, radius, diameter, circumference, chord, sector, segment, and arc. The angle subtended by a chord at the centre is twice that of the angle it subtends at the circumference. i.e $a = 2b$  $x = 2 \times 62^{\circ} = 124^{\circ}$	  Find the value of i. *m.* ii. *n*

120min	Same segment theorem	2.state the relationship between angles subtended by a chord at circumference in the same segment of a circle. 3.apply the relation to solve problems involving angles subtended by a chord at circumference in the same segment of a circle.	Let students know that angles subtended at the circumference in the same segment are equal. Assist students to solve problems involving angles subtended by a chord at circumference in the same segment of a circle.	 The angles subtended at the circumference in the same segment by a particular chord are equal. i. e. $a^\circ = b^\circ = c^\circ$.	 Find the value of *n*.
	Diameter theorem	4.find the value of the angle subtended by a diameter at the circumference 5.solve problems involving angles subtended by a diameter at the circumference.	Let students aware that the value of the angle subtended by a diameter at the circumference is 90° Assist students to solve problems involving angles subtended by a diameter at the circumference.	 Angle subtended by a diameter at the circumference is 90°.	  Find the value of

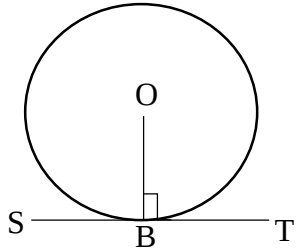
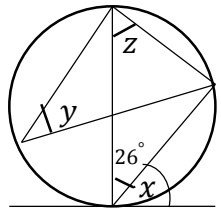
			POST PRESENTATION Recap the salient points and give exercise or assignment	 x +50°+90° = 180° x = 180° - 140° = 40°	i. x ii. y.

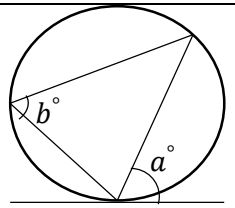
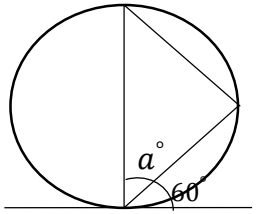
Control group lesson two

DATE/ TIME	SUBTOPIC	OBJECTIVES/ RPK	ACTIVITIES	CORE POINTS	EVALUATION
Thursday 15/10/20 9:00am- 11:00am	Opposite segment theorem	R.P.K. Students can identify parts of circle OBJECTIVES By the end of the lesson, the student will be able to; 1.state the relationship between angles at the circumference of opposite segment. 2.solve problems involving angles at the circumference of opposite segment	INTRODUCTION Assist students to recall parts of circle PRESENTATION Tell students the relationship between angles at the circumference of opposite segment. Assist students to solve problems involving angles at the	 Angles at the circumference of the opposite segment are supplementary. i. e. $a^\circ + b^\circ = 180^\circ$  $2 \times y = 100^\circ$ $y = 50^\circ$	Find the value of i. *y.* ii. *x* in the diagrams. 

120mim			circumference of opposite segment	Now, $x^\circ + y^\circ = 180^\circ$ $x + 50^\circ = 180^\circ$ $x = 180^\circ - 50^\circ$ $x = 130^\circ$	
	Exterior and opposite interior angle theorem	3.state the relationship between the exterior angle and opposite interior angle in a cyclic quadrilateral. 4.solve problems involving the exterior angle and opposite interior angle in a cyclic quadrilateral.	Explain the relationship between the exterior angle and opposite interior angle in a cyclic quadrilateral. Let students solve problems involving the exterior angle and opposite interior angle in a cyclic quadrilateral POST PRESENTATION Recap the salient points and give exercise or assignment	 In a cyclic quadrilateral, the exterior angle is equal to the opposite interior angle. i. e. $a^\circ = b^\circ$	Find the value of *a.* 

Control group lesson three

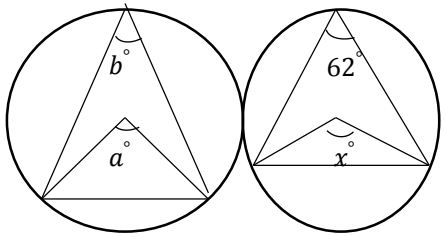
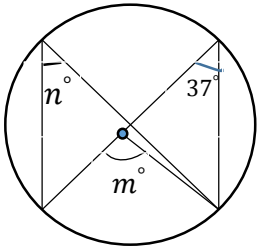
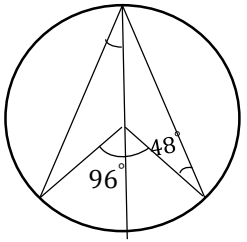
DATE	TOPIC	OBJECTIVES/ RPK	ACTIVITIES	CORE POINTS	EVALUATION
Tuesday 20/10/20 9:00am – 11:00am	GEOMETRY Perpendicularity of tangent and radius of a Circle	R.P.K. Students have learnt about angles of circle theorem. OBJECTIVES By the end of the lesson, the student will be able to; 1.apply the concept of tangent as perpendicular to the radius at the point of contact to related solve problems.	INTRODUCTION Revise the previous lesson on circle theorems. PRESENTATION Explain to students that the tangent is perpendicular to the radius at the point of contact. Let students solve problems involving perpendicularity of tangent and radius of a circle.	 The angle between the tangent and the radius at the point of contact is equal to 90°, i. e $\angle OBT = 90^{\circ}$	 Find the value of *x*, *y* and *z*

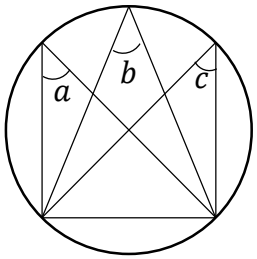
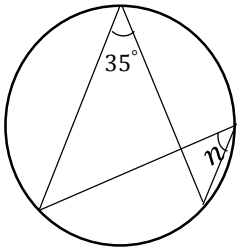
120 minutes	Alternate segment theorem	2.verify that the angle between the tangent and the chord at the point of contact is equal to the angle in the alternate segment	Explain to students that the angle between the tangent and the chord at the point of contact is equal to the angle in the alternate segment. Let students apply the idea of alternate segment theorem to solve related problems POST PRESENTATION Recap the salient points and give exercise or assignment.	 The angle between the tangent and the chord at the point of contact is equal to the angle in the alternate segment, i. e. $a^\circ = b^\circ$	 Find the value of *a.* REMARKS

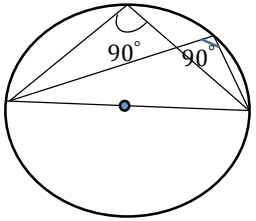
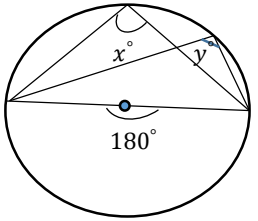
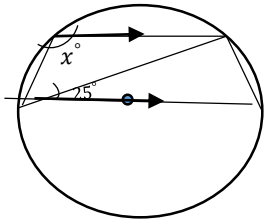
APPENDIX B

LESSON PLAN FOR THE EXPERIMENTAL GROUP

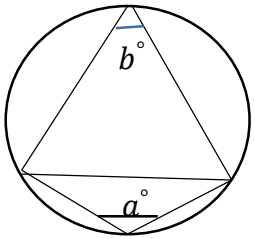
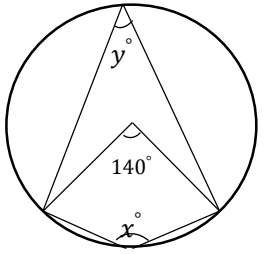
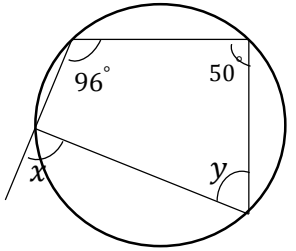
Experimental group lesson one

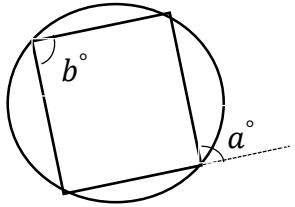
DATE	SUBTOPIC	OBJECTIVES/ RPK	ACTIVITIES	CORE POINTS	EVALUATION
Monday 12/10/20 8:00am – 10:00 am 120min	Centre and circumference theorem	R.P.K. Students can identify parts of circle OBJECTIVES By the end of the lesson, the student will be able to; 1. state the relationship between angle subtended at the centre and that at the circumference by an arc. 2. apply the relation to solving problems involving angle subtended at the centre and that at the circumference by an arc.	INTRODUCTION Assist students to recall parts of circle PRESENTATION Solve practical activity problems; Ask students to draw at least three circles using different radii. For each circle, draw a chord. Using the chord create angles at the centre and the circumference and assist students to solve until they recognise relationship between angle subtended at the centre and that at the circumference by an arc.	Parts of circle are; centre, radius, diameter, circumference, chord, sector, segment, and arc. The angle subtended by a chord at the centre is twice that of the angle it subtends at the circumference. i.e $a = 2b$  $x = 2 \times 62^{\circ} = 124^{\circ}$	  Find the value of iii. *m.* iv. *n*

	Same segment theorem	3.state the relationship between angles subtended by a chord at circumference in the same segment of a circle. 4.apply the relation to solving problems involving angles subtended by a chord at circumference in the same segment of a circle.	Present practical activity problems involving angles subtended at the circumference in the same segment and assist students to solve by drawing and measuring. Students guess correctly the relationship between angles subtended by a chord at circumference in the same segment of a circle. Students apply relation to solve problems involving angles subtended by a chord at circumference in the same segment of a circle.	 The angles subtended at the circumference in the same segment by a particular chord are equal. i. e. $a^\circ = b^\circ = c^\circ$.	 Find the value of *n.*

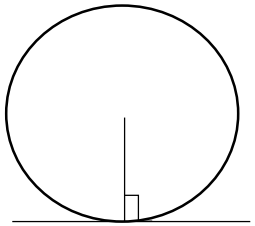
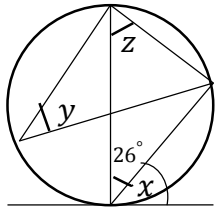
	Diameter	5.solve problems involving angles subtended by a diameter at the circumference.	Take students through practical activity involving angles subtended by a diameter at the circumference and let students draw and measure the value of the angle subtended by a diameter at the circumference. Students use the idea of angle subtended by a chord at the centre is twice that of the angle it subtends at the circumference to solve until they realize that angle subtended by a diameter at the circumference is 90°. POST PRESENTATION Recap the salient points and give exercise or assignment	 Angle subtended by a diameter at the circumference is 90°.	  Find the value of iii. *x* iv. *y*.

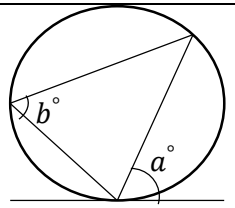
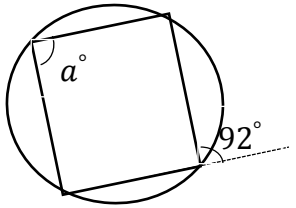
Experimental group lesson two

DATE/ TIME	SUBTOPIC	OBJECTIVES/ RPK	ACTIVITIES	CORE POINTS	EVALUATION
Wednesday 14/10/20 9:00am-11:00am 120mim	Opposite segment theorem	R.P.K. Students have learnt about same segment theorem and diameter theorem. OBJECTIVES By the end of the lesson, the student will be able to; 1.state the relationship between angles at the circumference of opposite segment. 2.solve problems involving angles at the circumference of opposite segment	INTRODUCTION Assist students to recall facts about same segment theorem and diameter theorem PRESENTATION Guide students to draw and measure angles at opposite segment, add them up and compare to 180° assists students identify the relationship between angles at the circumference of opposite segment and ask students to use the concept from angle subtended by a chord at the centre is twice that of the angle it subtends at the circumference.	 Angles at the circumference of opposite segment are supplementary. i. e. $a^\circ + b^\circ = 180^\circ$	Find the value of iii. y. iv. x in the diagrams.  

			Until students arrive at the conclusion that angles at the circumference of opposite segment are supplementary.		
	Exterior and opposite interior angle theorem	3.state the relationship between the exterior angle and opposite interior angle in a cyclic quadrilateral. 2.solve problems involving the exterior angle and opposite interior angle in a cyclic quadrilateral.	Draw a rectangle in a circle. Ask questions that lead students to discover correctly, the relationship between the exterior angle and opposite interior angle in a cyclic quadrilateral. Let students solve problems involving the exterior angle and opposite interior angle in a cyclic quadrilateral POST PRESENTATION Recap the salient points and give exercise or assignment	 In a cyclic quadrilateral, the exterior angle is equal to the opposite interior angle. i. e. $a^\circ = b^\circ$	

Experimental group lesson three

DATE	TOPIC	OBJECTIVES/ RPK	ACTIVITIES	CORE POINTS	EVALUATION
Monday 19/10/20 9:00am – 11:00am 1200 minutes	GEOMETRY Perpendicularity of tangent and radius of a Circle	R.P.K. Students have learnt about circle theorem. OBJECTIVES By the end of the lesson, the student will be able to; 1.apply the concept of tangent as perpendicular to the radius at the point of contact to related solve problems	INTRODUCTION Revise the previous lesson on circle theorems. PRESENTATION Give practical tasks to students draw and measure angles at point of contact. Assist students discover tangent being perpendicular to the radius at the point of contact. Let students to solve problems involving perpendicularity of tangent and radius of a Circle.	 The angle between the tangent and the radius at the point of contact is equal to 90°, i. e $\angle OBT = 90^{\circ}$	 Find the value of *x*, *y* and *z*

	Alternate segment theorem	2.identify the angle between the tangent and the chord at the point of contact in the alternate segment 3. apply the idea of alternate segment theorem to solve related problems	Guide students through practical questions involving alternate segment theorem and guide students to draw and measure angles until they realize that angle between the tangent and the chord at the point of contact is equal to the angle in the alternate segment. Let students apply the idea of alternate segment theorem to solve related problems POST PRESENTATION Recap the salient points and give exercise or assignment.	 The angle between the tangent and the chord at the point of contact is equal to the angle in the alternate segment, i. e. $a^\circ = b^\circ$	 Find the value of *a.* REMARKS

APPENDIX C

UNIVERSITY OF CAPE COAST

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

CIRCLE THEOREMS ACHIEVEMENT TEST 1 (PRE-TEST)

Duration: 1 hour

This test is to help the researcher to collect data on "use of inductive teaching method and its effect on senior high school students' achievement in circle theorems". The study is solely for academic purposes. Please, kindly provide sincere and objective responses to the questions.

SECTION A

Please, put a check mark (√) where appropriate in the box corresponding to your choice.

A. Participant ID: ☐

B. Sex: Male ☐ Female ☐

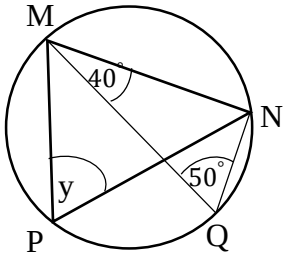
C. Age: 14-17 years ☐ 18-21 years ☐ 22 years or more ☐

D. School: A ☐ B ☐

SECTION B (10 MARKS)

Circle the letter of the correct answer

1. In the diagram, *MN* is a chord, angle *MQN* = 50° and angle *QMN* = 40°. Find the value of the angle marked *y*.



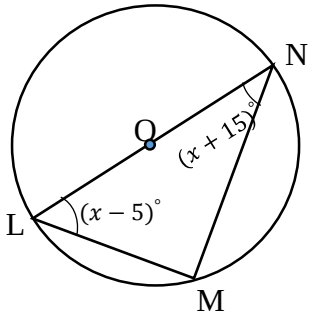
A. 60°

B. 50°

C. 40°

D. 25°

2. The diagram shows a triangle inscribed in a circle of centre *O*. If $\angle LNM = (x + 15)^{\circ}$ and $\angle NLM = (x - 5)^{\circ}$, find the value of *x*.



A. 35°

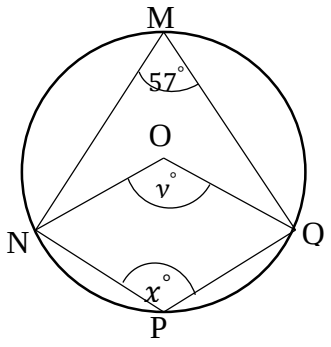
B. 40°

C. 45°

D. 50°

*Use the information below to answer questions **3** and **4**.*

In the diagram, *O* is the centre of the circle *MNPQ* and $\angle NMQ = 57^\circ$.



3. Find the value of *y*.

A. 57°

B. 114°

C. 123°

D. 246°

4. Find the value of *x*.

A. 57°

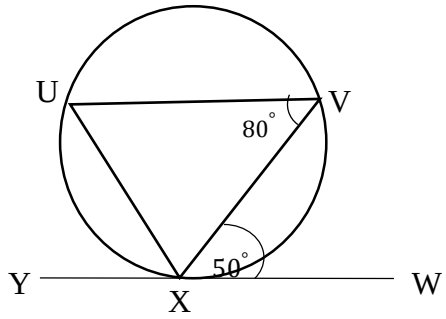
B. 114°

C. 123°

D. 246°

Use the information below to answer questions 5 and 6.

In the diagram, /*YW*/ is a tangent to the circle at X, /*UV*/ = /*VX*/ and angle *VXW* = 50°.



5. Find the value $\angle VUX$.

   A. 50°

   B. 70°

   C. 80°

   D. 90°

6. Find the value $\angle UXY$.

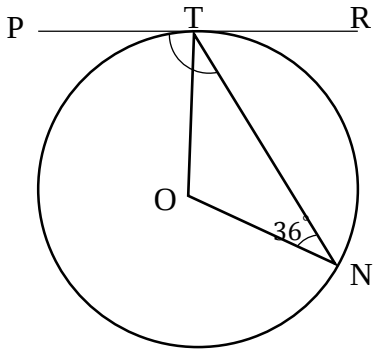
   A. 50°

   B. 70°

   C. 80°

   D. 90°

7. In the diagram, *PTR* is a tangent to the circle centre O. If angle *ONT* = 36°, calculate the size of angle *PTN*.



   A. 132°

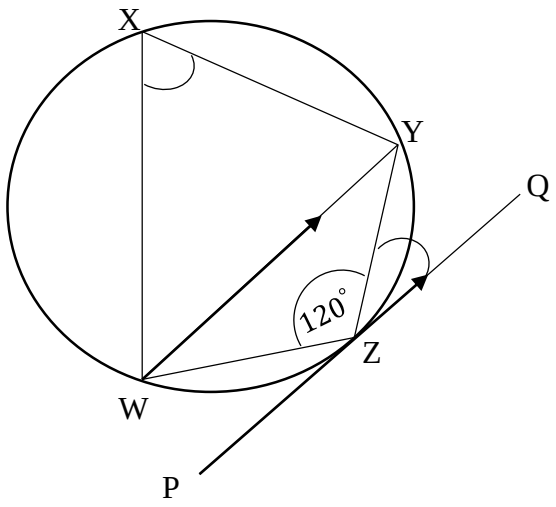
   B. 126°

   C. 108°

   D. 102°

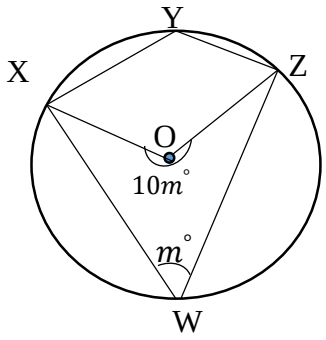
Use the information below to answer questions 8 and 9.

In the diagram, *PQ* is a tangent to the circle at Z. If *PQ*//*WY*, $\angle WZY = 120^\circ$, $\angle WXY = m$ and $\angle YZQ = x$.



8. Find the value of *m*.
   A. 120°
   B. 80°
   C. 60°
   D. 40°
9. Find the value of *x*.
   A. 30°
   B. 60°
   C. 75°
   D. 80°

10. In the diagram, *O* is the centre of the circle, reflex angle XOZ = $10m^{\circ}$ and ∠XWZ = m°. Find the value of *m*.



A. 30°

B. 36°

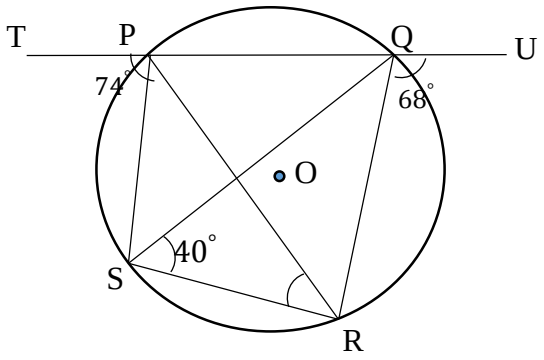
C. 40°

D. 72°

SECTION C

Answer all questions. Show all necessary details of working, including rough work with the answer in the space below.

11. The diagram shows a circle *PQRS* with centre *O*, $\angle UQR = 68^\circ$, $\angle SPT = 74^\circ$, and $\angle QSR = 40^\circ$. Calculate the value of $\angle SRP$.



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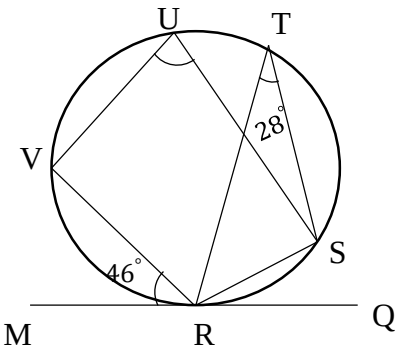
12. In the diagram, $\angle RTS = 28^\circ$, $\angle VRM = 46^\circ$, MQ is a tangent to the circle VRSTU at the point R. Find $\angle VUS$.



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APPENDIX D

UNIVERSITY OF CAPE COAST

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

GEOMETRY ACHIEVEMENT TEST 2 (POST-TEST)

Duration: 1 hour

This test is to help the researcher to collect data on "use of inductive teaching method and its effect on senior high school students' achievement in circle theorems". The study is solely for academic purposes. Please, kindly provide sincere and objective responses to the questions.

SECTION A

Please, put a check mark (√) where appropriate in the box corresponding to your choice.

A. Participant ID: ☐

B. Sex: Male ☐ Female ☐

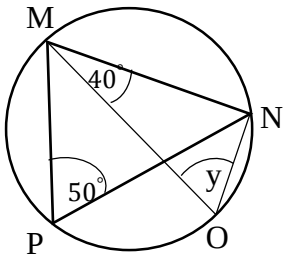
C. Age: 14-17 years ☐ 18-21 years ☐ 22 years or more ☐

D. School: A ☐ B ☐

SECTION B (10 MARKS)

Circle the letter of the correct answer

1. In the diagram, *MN* is a chord, angle *MPN* = 50° and angle *QMN* = 40°. Find the value of the angle marked *y*.



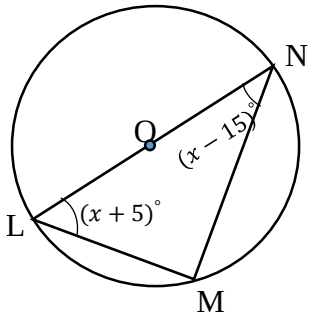
A. 90°

B. 50°

C. 40°

D. 25°

2. The diagram shows a triangle inscribed in a circle of centre *O*. If angle $\angle LNM = (x - 15)^\circ$ and $\angle NLM = (x + 5)^\circ$, find the value of *x*.



A. 35°

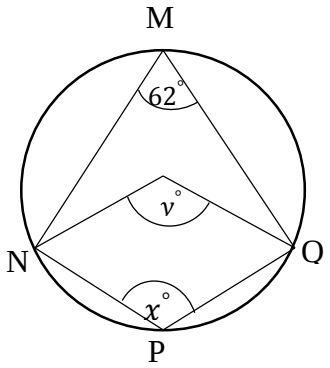
B. 40°

C. 45°

D. 50°

*Use the information below to answer questions **3** and **4**.*

In the diagram, *O* is the centre of the circle *MNPQ* and $\angle NMQ = 62^\circ$.



3. Find the value of *y*.

A. 31°

B. 62°

C. 118°

D. 124°

4. Find the value of *x*.

   A. 31°

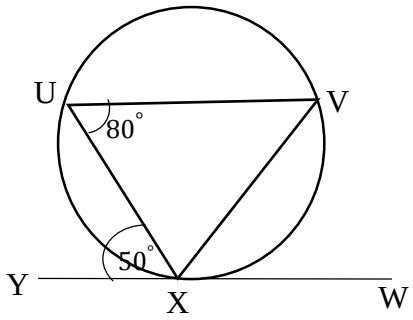
   B. 62°

   C. 118°

   D. 124°

*Use the information below to answer questions **5** and **6**.*

In the diagram, /*YW*/ is a tangent to the circle at X, angle VUX= 80° and angle *YXU* = 50°.



5. Find the value ∠*UVX*.

   A. 50°

   B. 70°

   C. 80°

   D. 85°

6. Find the value ∠*UXV*.

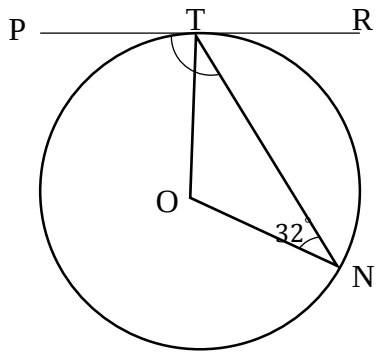
   A. 50°

   B. 70°

   C. 80°

   D. 85°

7. In the diagram, *PTR* is a tangent to the circle centre O. If angle *ONT* = 32°, calculate the size of angle *PTN*.



A. 148°

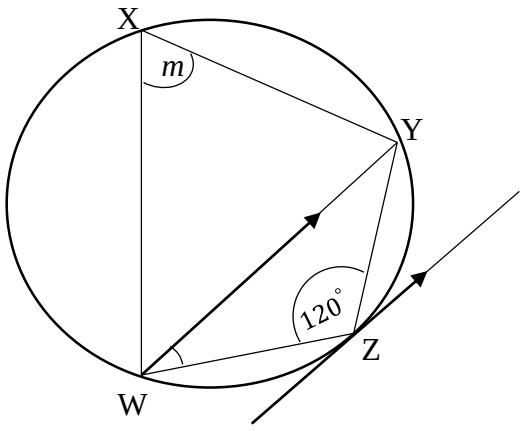
B. 122°

C. 64°

D. 58°

Use the information below to answer questions 8 and 9.

In the diagram, *PQ* is a tangent to the circle at Z. If *PQ*//*WY*, $\angle WZY = 120^\circ$, $\angle WXY = m$, $\angle WYZ = y$.



8. Find the value of *m.*

   A. 120°

   B. 80°

   C. 60°

   D. 40°

9. Find the value of *y.*

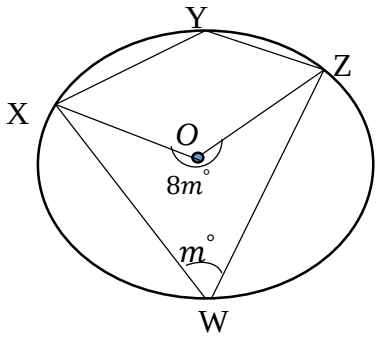
   A. 30°

   B. 60°

   C. 80°

   D. 85°

10. In the diagram, o is the centre of the circle *O*, reflex angle XOZ = $8m^\circ$ and $\angle$XWZ = m°. Find the value of *m.*



   A. 30

   B. 36

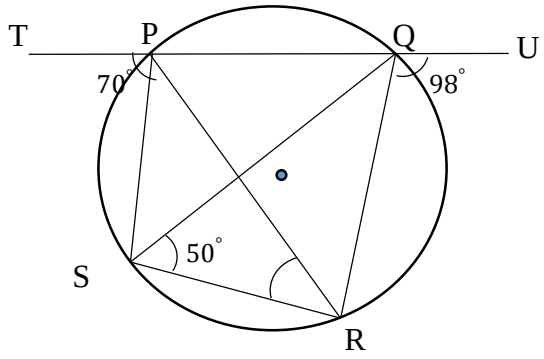
   C. 40

   D. 72

SECTION C (10 MARKS)

Answer all questions. Show all necessary details of working, including rough work with the answer in the space below.

11. The diagram shows a circle *PQRS* with centre *O*, $\angle UQR = 98^\circ$, $\angle TPS = 70^\circ$, and $\angle QSR = 50^\circ$. Calculate the value of $\angle SRP$.



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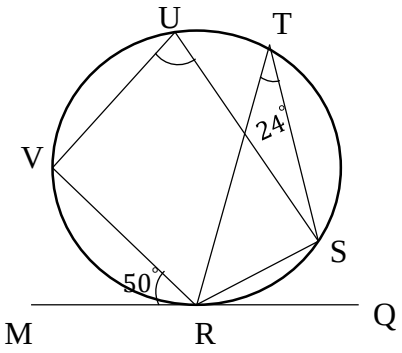
12. In the diagram, $\angle RTS = 24^\circ$, $\angle VRM = 50^\circ$, MQ is a tangent to the circle VRSTU at the point R. Find $\angle VUS$.



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APPENDIX E

UNIVERSITY OF CAPE COAST

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

CIRCLE THEOREM ACHIEVEMENT TEST 1 (PRE-TEST)

MARKING SCHEME

SECTION B (10 marks)

1. B 2. B 3. B 4. C 5. A 6. C 7. B 8. C 9. A 10. A

SECTION C (10 marks)

Question	Details	Marks
11.	$\angle UQP = \angle PSR$ $\angle UQP = \angle PSQ + \angle QSR$ $68^\circ = \angle PSQ + 40^\circ$ $\angle PSQ = 68^\circ - 40^\circ$ $\angle PSQ = 28^\circ$ $\angle PSQ = < PRQ = 28^\circ$ $\angle TPS = < SRQ$ $\angle TPS = < SRP + < PRQ$ $74^\circ = \angle SRP + 28^\circ$ $\angle SRP = 74^\circ - 28^\circ$ $\angle SRP = 46^\circ$	**M1** for solving/ subtraction **A1** for 28 **B1 (** same segment**)** **M1** for subtraction **A1** for 46 [**5 *marks***]
12.	$\angle QRS = < RTS = 28^\circ$ $\angle MRV + \angle VRS + \angle SRQ = 180^\circ$ $46^\circ + \angle VRS + 28^\circ = 180^\circ$ $\angle VRS = 180^\circ - 74^\circ$ $\angle VRS = 106^\circ$ $\angle VRS + \angle VUS = 180^\circ$ $106^\circ + \angle VUS = 180^\circ$ $\angle VUS = 180^\circ - 106$ $\angle VUS = 74^\circ$	**B1** (alternate segment) **M1** for solving/ subtraction **A1** **M1** for solving or subtraction **A1** for 74 [**5 *marks***] **Total = 10 marks**

APPENDIX F

UNIVERSITY OF CAPE COAST

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

GEOMETRY ACHIEVEMENT TEST 2 (POST-TEST)

MARKING SCHEME

SECTION B (10 marks)

1. B 2. D 3. D 4. C 5. A 6. A 7. B 8. C 9. A 10. B

SECTION C (10 marks)

Question	Details	Marks
11.	$\angle UQP = \angle PSR$ $\angle UQP = \angle PSQ + \angle QSR$ $98^\circ = \angle PSQ + 50^\circ$ $\angle PSQ = 98^\circ - 50^\circ$ $\angle PSQ = 48^\circ$ $\angle PSQ = < PRQ = 48^\circ$ $\angle TPS = \angle SRQ$ $\angle TPS = \angle SRP + \angle PRQ$ $70^\circ = \angle SRP + 48^\circ$ $\angle SRP = 70^\circ - 48^\circ$ $\angle SRP = 22^\circ$	**M1** for solving/subtraction **A1** for 48 **B1 (** same segment**)** **M1** for subtraction **A1** for 22 [**5 *marks***]
12.	$\angle QRS = \angle RTS = 24^\circ$ $\angle MRV + \angle VRS + \angle SRQ = 180^\circ$ $50^\circ + \angle VRS + 24^\circ = 180^\circ$ $\angle VRS = 180^\circ - 74^\circ$ $\angle VRS = 106^\circ$ $\angle VRS + \angle VUS = 180^\circ$ $106^\circ + \angle VUS = 180^\circ$ $\angle VUS = 180^\circ - 106$ $\angle VUS = 74^\circ$	**B1** (alternate segment) **M1** for solving/subtraction **A1** **M1** for solving/subtraction **A1** for 74 [**5 *marks***] **Total = 10 marks**

Grand Total = 20 marks

APPENDIX G

Distribution of pre-test raw scores of students in the groups.

Control Group		Experimental Group	
Students	Scores (out of 20)	**Students**	Scores (out of 20)
1	6.00	**1**	2.00
2	4.00	**2**	1.00
3	6.00	**3**	3.00
4	2.00	**4**	1.00
5	1.00	**5**	4.00
6	4.00	**6**	4.00
7	5.00	**7**	3.00
8	5.00	**8**	2.00
9	2.00	**9**	2.00
10	2.00	**10**	5.00
11	4.00	**11**	1.00
12	4.00	**12**	6.00
13	13.00	**13**	3.00
14	5.00	**14**	6.00
15	3.00	**15**	3.00
16	1.00	**16**	5.00
17	5.00	**17**	2.00
18	11.00	**18**	6.00
19	11.00	**19**	1.00
20	10.00	**20**	5.00
21	8.00	**21**	5.00
22	8.00	**22**	6.00
23	8.00	**23**	1.00
24	5.00	**24**	6.00
25	5.00	**25**	7.00

Distribution of pre-test raw scores (continues)

Control Group		Experimental Group	
Students	Scores (out of 20)	**Students**	Scores (out of 20)
26	3.00	**26**	6.00
27	9.00	**27**	4.00
28	6.00	**28**	4.00
29	3.00	**29**	7.00
30	5.00	**30**	3.00
31	8.00	**31**	3.00
32	5.00	**32**	4.00
33	3.00	**33**	.00
34	12.00	**34**	9.00
35	3.00	**35**	13.00
36	7.00	**36**	3.00
37	3.00	**37**	3.00
38	8.00	**38**	3.00
39	6.00	**39**	3.00
40	8.00	**40**	3.00
41	6.00	**41**	5.00
42	7.00	**42**	4.00
43	5.00	**43**	11.00
44	11.00	**44**	1.00
45	4.00	**45**	5.00
46	2.00	**46**	4.00
47	5.00	**47**	4.00
48	6.00	**48**	4.00
49	5.00	**49**	2.00
50	7.00	**50**	8.00
51	4.00	**51**	7.00

Distribution of pre-test raw scores (continues)

Control Group		Experimental Goup	
Students	Scores (out of 20)	Students	Scores (out of 20)
52	5.00	**52**	4.00
53	7.00	**53**	.00
54	8.00	**54**	4.00
55	4.00	**55**	12.00
56	4.00	**56**	2.00
57	4.00	**57**	7.00
58	3.00	**58**	5.00
59	11.00	**59**	5.00
60	4.00	**60**	5.00
61	2.00	**61**	5.00
62	2.00	**62**	4.00
63	3.00	**63**	3.00
64	11.00	**64**	3.00
65	5.00	**65**	2.00
66	3.00	**66**	2.00
67	2.00	**67**	4.00
68	4.00	**68**	2.00
69	6.00	**69**	2.00
70	5.00	**70**	3.00
71	4.00	**71**	6.00
72	3.00	**72**	6.00
73	2.00	**73**	3.00
74	2.00	**74**	6.00
75	6.00	**75**	4.00
76	10.00	**76**	4.00
77	4.00	**77**	3.00

Distribution of pre-test raw scores (continues)

Control Group		Experimental Group	
Students	Scores (out of 20)	Students	Scores (out of 20)
78	3.00	**78**	2.00
79	4.00	**79**	1.00
80	7.00	**80**	2.00
		81	5.00
		82	9.00

APPENDIX H

Distribution of post-test raw scores of students in the groups.

Control Group		Experimental Group	
Students	Scores (out of 20)	Students	Scores (out of 20)
1	16.00	**1**	15.00
2	12.00	**2**	8.00
3	16.00	**3**	15.00
4	8.00	**4**	10.00
5	12.00	**5**	18.00
6	12.00	**6**	16.00
7	12.00	**7**	15.00
8	11.00	**8**	16.00
9	10.00	**9**	15.00
10	5.00	**10**	19.00
11	13.00	**11**	8.00
12	13.00	**12**	20.00
13	17.00	**13**	16.00
14	14.00	**14**	20.00
15	10.00	**15**	15.00
16	7.00	**16**	15.00
17	13.00	**17**	18.00
18	18.00	**18**	14.00
19	19.00	**19**	20.00

Distribution of post-test raw scores (continues)

Control Group		Experimental Group	
Student	Scores (out of 20)	Student	Scores (out of 20)
20	19.00	**20**	12.00
21	18.00	**21**	19.00
22	20.00	**22**	20.00
23	18.00	**23**	7.00
24	14.00	**24**	20.00
25	11.00	**25**	20.00
26	13.00	**26**	13.00
27	17.00	**27**	17.00
28	16.00	**28**	20.00
29	10.00	**29**	20.00
30	15.00	**30**	16.00
31	17.00	**31**	15.00
32	16.00	**32**	17.00
33	10.00	**33**	7.00
34	10.00	**34**	20.00
35	8.00	**35**	20.00
36	17.00	**36**	17.00
37	13.00	**37**	17.00
38	18.00	**38**	18.00
39	18.00	**39**	17.00
40	18.00	**40**	18.00
41	17.00	**41**	20.00
42	15.00	**42**	19.00
43	15.00	**43**	20.00
44	6.00	**44**	12.00
45	10.00	**45**	13.00
46	13.00	**46**	20.00
47	16.00	**47**	19.00

Distribution of post-test raw scores (continues)

Control Group		Experimental Group	
Student	Scores (out of 20)	Student	Scores (out of 20)
48	16.00	**48**	19.00
49	16.00	**49**	17.00
50	19.00	**50**	20.00
51	14.00	**51**	20.00
52	17.00	**52**	19.00
53	19.00	**53**	7.00
54	19.00	**54**	17.00
55	3.00	**55**	20.00
56	11.00	**56**	14.00
57	13.00	**57**	20.00
58	10.00	**58**	20.00
59	7.00	**59**	18.00
60	16.00	**60**	19.00
61	9.00	**61**	20.00
62	9.00	**62**	18.00
63	13.00	**63**	17.00
64	8.00	**64**	16.00
65	17.00	**65**	12.00
66	14.00	**66**	10.00
67	7.00	**67**	18.00
68	11.00	**68**	13.00
69	16.00	**69**	11.00
70	16.00	**70**	16.00
71	16.00	**71**	20.00
72	13.00	**72**	20.00
73	12.00	**73**	20.00
74	11.00	**74**	15.00
75	18.00	**75**	19.00

Distribution of post-test raw scores (continues)

Control Group		Experimental Group	
Student	Scores (out of 20)	Student	Scores (out of 20)
76	20.00	**76**	19.00
77	12.00	**77**	13.00
78	12.00	**78**	14.00
79	11.00	**79**	8.00
80	18.00	**80**	14.00
		81	12.00
		82	19.00

APPENDIX I

ETHICAL CLEARANCE REQUEST

UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
DEPARTMENT OF MATHEMATICS AND I.C.T EDUCATION

Telephone: 0332096951
Telex: 2552, UCC, GH
Telegrams & Cables: University, Cape Coast
Email: dmicte@ucc.edu.gh

University Post Office
Cape Coast, Ghana

Your Ref:

Our Ref: DMICTE/P.3/V.1/069

Date: 8th June, 2020

The Director
Institutional Review Board
University of Cape Coast
Cape Coast

Dear Sir,

REQUEST FOR ETHICAL CLEARANCE

I write as a supervisor to introduce my student Mr. Constant Richard Segbefia, with registration number ET/MDP/18/0001 an MPhil (Mathematics Education) student of the Department of Mathematics and ICT Education, College of Education Studies, University of Cape Coast.

As part of the requirement for the award of a master's degree, he is required to undertake a research on the topic **"USE OF INDUCTIVE TEACHING METHOD ON SENIOR HIGH SCHOOL STUDENTS' ACHIEVEMENT AND RETENTION IN GEOMETRY"**

I would be grateful if you could give him the necessary assistance he may need.

Thanks for your usual support.

Yours faithfully,

Dr Kofi Ayebi-Arthur
HEAD

APPENDIX J

ETHICAL CLEARANCE APPROVAL LETTER

UNIVERSITY OF CAPE COAST
INSTITUTIONAL REVIEW BOARD SECRETARIAT
TEL: 0558093143 / 0508878309/ 0244207814
E-MAIL: irb@ucc.edu.gh
C/O Directorate of Research, Innovation and Consultancy
OUR REF: UCC/IRB/A/2016/786
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

28TH AUGUST, 2020

Mr. Constant Richard Segbefia
Department of Mathematics and ICT Education
University of Cape Coast

Dear Mr. Segbefia,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2020/58)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted **Provisional Approval** for the implementation of your research protocol **Use of Inductive Teaching Method and its Effect on Senior High School Students' Achievement and Retention in Geometry.** This approval is valid from 28th August, 2020 to 27th August, 2021. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST