Frontiers of Contemporary Education
ISSN 2690-3520 (Print) ISSN 2690-3539 (Online)
Vol. 3, No. 3, 2022
www.scholink.org/ojs/index.php/fce

Original Paper

Effect of Inquiry-based Teaching Approach on Students Achievement in Circle Theorems

Gabina Susuoroka[1*], Richmond Adu-Gyamfi[2], Emmanuel Boakye Adubofour[2], Al-hassan Abdul-Mumin[2] & Dennis Offei Kwakye[3]

[1] Department of Business Education, University of Business and Integrated Development Studies-UBIDS, Wa, Ghana

[2] Department of Mathematics, Ola SHS, NJA College of Education, Ghana

[3] Department of mathematics and ICT, C. K. Tedam University of Technology and Applied Sciences, Navrongo, Ghana

[*] Gabina Susuoroka, E-mail: susuorokag@yahoo.com

Authors' contribution:

- Theoretical and conceptual framework: Gabina Susuoroka, Richmond Adu-Gyamfi, Emmanuel Boakye Adubofour, Al-hassan Abdul-Mumin & Dennis Offei Kwakye
- Design and typesetting: Gabina Susuoroka, Richmond Adu-Gyamfi, Emmanuel Boakye Adubofour, Al-hassan Abdul-Mumin & Dennis Offei Kwakye
- Data collection: Gabina Susuoroka, Richmond Adu-Gyamfi, Emmanuel Boakye Adubofour
- Analysis and interpretation: Gabina Susuoroka, Richmond Adu-Gyamfi, Emmanuel Boakye Adubofour, Al-hassan Abdul-Mumin & Dennis Offei Kwakye
- Supervision and Guidance: Gabina Susuoroka, Richmond Adu-Gyamfi, Dennis Offei Kwakye

Received: June 15, 2022 Accepted: July 6, 2022 Online Published: September 20, 2022
doi:10.22158/fce.v3n3p1 URL: http://dx.doi.org/10.22158/fce.v3n3p1

Abstract

This study investigated the effect of inquiry-based teaching approach on students' achievement in Circle theorems in Senior High Schools. The study used sequential exploratory mixed method research design tocollect quantitative and qualitative data to answer the various research questions. A sample of 105 students and 6 mathematics teachers from the two schools were randomly and conveniently selected respectively for the study. Circle Theorems Achievement Tests (CTAT) was administered to both intact classes (control andexperimental) as pre-test and after the intervention a similar CTAT was administered as post-test. During treatment, the experimental group were taken through inquiry- based teaching approach instruction while the traditional instruction was applied to *the control group. Results from paired sample t-test showed that participants in the experimental group had increment in their post-test as compared to the pre-test. However, independent samples t-test results revealed that students in the experimentalgroup achieved better in the post-test as compared to those in the control group. Interview data showed students negative attitudes and teachers' teaching methods (useof traditional teaching method) were the main cause of students' poor performance in circle theorems. The observation data also revealed that time factor was challenging since inquiry class activities needed more time to complete and also forming the smallgroups was a challenge in the class due to large class size and classroom not spacious. In conclusion, inquiry-based teaching approach was found to increased students' achievement in circle theorem than the traditional instruction and hence recommendedfor teachers to implement it in their teaching.*

Keywords

Circle, Theorem, Inquiry-Based, Teaching, Achievement and Students

1. Introduction

Mathematics is one of the most useful subjects worldwide. In view of this, its importance in everyday life cannot be undermined. The main objective of teaching mathematics at all levels is to enable the learner develop clear and logical thinking needed for analysis of both academic and everyday life situation (Scopes, 1973). Thus, mathematics aids in understanding other subjects, especially the science subjects. Mathematics is necessary for the development of scientific, technical, monetary and commercial activities around the life of an individual and the community (Ayot & Patel, 1992). Mathematics has become a compulsory subject up to a certain academic level in almost every nation of the world. According to Kinyua, Maina, and Odera (2003), mathematics helps the students to improve their skills in measurement, approximation and estimating. Such skills are necessary for any quest be it academic or business. The importance of mathematics is also highlighted by National Council of Teachers of Mathematics (2003) that "those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their future" (p. 5). Every student must study mathematics during the educational process for their personal development and achievement in today's technological and progressing world. The mastery of mathematics is a key literacy component that influences children's success in education and in future society (Engle, Grantham-McGregor, Black, Walker & Wachs, 2007). Asiedu-Addo and Yidana (2000) asserted that mathematics builds individual's reasoning and problem-solving abilities, and also develops his/her personal qualities which includeconfidence, diligence, perseverance and cooperation.

Secondary school mathematics is designed to help students in working out solutions to problems with accuracy, precision and speed both academic and functional life situation. The core mathematics syllabus at Senior High School (SHS) level in Ghana, is made up of the following content domains: Numbers and Numeration, Plane Geometry, Algebra, Vectors and Transformation in a Plane, Statistics and Probability,Trigonometry and Mensuration (Ministry of Education, 2010). Geometry, which is the main focus of this study places emphasis on circle theorems. Geometry is a branchof mathematics that provides a rich source of visualization for understanding arithmetic, algebraic, and statistical concepts (Drickey, 2001). As such, the teaching and learning of geometry is very essential in everyday life since it provides a more complete appreciation of the world, we live in. The reason being that it appears naturally in the structure of the solar system, in geological formation of some rocks and crystals, in plants and flowers, and even in animals (Lie & Hafizah, 2008). Circle theorems is considered as a very important aspect of geometry. Its application is seen in ship navigation. Due to the usefulness of geometry in everyday life, it is not surprising that most international examinations always have some aspect of it. Examples of these examinations are the Trends in International Mathematics and Science Study (TIMSS), West African Senior School Certificate Examination (WASSCE), etc.

Students showed high level of difficulty in identifying angles subtended at the centre and at the circumference by an arc. Moreover, in questions relating to angles subtended by a diameter at the circumference majority of the students encountered difficulties in the area of recognizing the theorem to be used as well as writing the correct mathematical statements. How well students retain taught circle theorems concept can be traced back to the teachers' teaching approach used in class. Furthermore, there is empirical evidence that many students in Ghana face difficulties in solving questions involving geometry concepts (Baffoe & Mereku, 2010). This suggests that SHS students find geometry concepts difficult and mathematics teachers are faced with the challenge of how to present geometry concepts to students to promote conceptual understanding.

As a result, the methods of teaching mathematics should be of great importance to mathematics educators. Generally, teaching requires that, the teacher creates an environment in which students are active leaners. Teaching also requires that the teacher integrates a range of assessment methods into their instruction to enhance students understanding (National Board for Professional Teaching Standards, 2009). Understanding mathematics means being able to justify procedures used or state why the process works. In other words, real understanding of mathematics concept is achieved when it is taught through proofs (Wiggins, 2016). Unfortunately, mathematics teachers in sub-Saharan Africa use the traditional method of teaching in their lessons where concepts are taught by giving a set of rules to students to be followed without the students knowing how those concepts came about (Akyeampong, Lussier, Pryor & Westbrook, 2013). According to Wood and Gentile (2003), educators are beginning to recognize that there are better ways to learn other than through the traditional methods. The traditional method of teaching, is passive rather than active. Students are made to act as spectators rather than partakers in the learning process. Also, the traditional method of teaching does not enhance critical thinking and collaborative problem-solving since "chew and pour" is the order of the day. Students should be exposed to skills in creating their own knowledge in order to enhance understanding of mathematical concepts rather than providing them with a set of rules without understanding. In order for the students to think mathematically, students should be exposed to various strategies of problem solving. One of such strategies is inquire-based teaching approach. Inquiry-based teaching approach is a method of teaching in which teachers allow students to learn through investigations and discovery. According to Spronken-Smith (2007), inquiry-based learning is a pedagogy which enables students experience the processes of knowledge creation and the key attribute is learning stimulated by an inquiry is student centred, a more to self-directed learning and an active approach to learning. Similarly, Friesen and Scott (2013) also defined inquiry-based learning as anapproach to teaching and learning that places student's questions, ideas and observations at the center of the learning experience. According to Minner, Levy, and Century (2010), inquiry-based teaching strategy actively engage students in the learning process through scientific investigations which increase conceptual understanding. There is a positive impact in the student learning outcome when an inquiry-based learning method is used instead of traditional lecture-based learning (Minner, Levy & Century, 2010). With inquiry learning, students engage in learning by drawing upon their prior knowledge and experiences. Inquiry learning uses the student's prior knowledge as a building block to integrate new understandings with prior learning (Lemlech, 1998). Learning has more meaning for students as it becomes a more relevant part of their lives and they begin to better understand the world around them. Inquiry-based learning involves students' in explorations, theory building, and experimentation. It encourages active thinking and seeking rather than rote memorization. As stated by Baker et al. (2008), in our view, encouraging students' problem solving and creative thinking is far better than testing their ability to memorize. The goal [of inquiry learning] is to help students develop skills that enable them to construct vital concepts and challenge their ingrained misconceptions.

Inquiry learning is a student-centred approach that allows students to have more control over their process of knowledge-getting. Consequently, students are motivated by inquiry learning. Not only because students are actively involved in the process but because the expectation of finding the answer motivates the search for it as confirmed by Slavin (2006) that it arouses students' curiosities and motivates students to continue to seek until they find answers. Inquiry-based learning develops independent problem-solving and critical-thinking skills in students, which is a benefit for both students and teachers. Lemlech (1998) stated that the goal of inquiry learning should be to challenge the student to engage in activity that requires higher level thinking and reflective processes. Inquiry-based learning also emphasizes students' understanding concepts rather than acquiring skills. Inquiry-based learning encourages teachers to move away from the tradition in which knowledge is viewedas discrete, hierarchical, sequential, and fixed and toward an environment in which knowledge is viewed as an individual construction created by the learner (Draper, 2002). Inquiry-based learning offers students opportunities to discover knowledge by themselves (Longo, 2010). Students are allowed to discuss their own perspectives, reflect on the process of exploration, and explain their choices (Michalopoulou, 2014).

1.1 Statement of the Problem

In discharging our duties in the classroom as mathematics teachers, we often encounter a lot of problems faced by learners. These problems sometimes discourage students in their learning of mathematics and eventually cause their failure in the subject. This came to light as a result of students showing fewer interest in circle theorems lessons leading to scoring low marks on circle theorems. Students showed high level of difficulty in identifying angles subtended at the centre and at the circumference by an arc, the relationship between the angles between the tangent and cord at the point of contact and angle in the alternate segment and the relationship between opposite angles of a cyclic quadrilateral. Moreover, questions relating to angles subtended by a diameter at the circumference and properties of parallel lines majority of the students encountered difficulties in the area of recognizing the theorem to be used as well as writing the correct mathematical statements (see Appendix A).

Based on information gathered by the researcher, Teachers in the district still use traditional or teacher centred method to teach circle theorems. Traditional or teacher centred method makes students passive, act as spectators in the learning process, does not enhance critical thinking and collaborative problem-solving. In order for students to perform better in circle theorems, teachers should use student centred method such as inquiry-based teaching approach. In inquiry-based teaching approach, teachers allow students to learn through investigations and discovery, develops independent problem-solving and critical-thinking skills and emphasizes on students' understanding concepts. This study therefore, sought to investigate the effectiveness of inquiry-based teaching approach in circle theorem in senior high schools in Asutifi North District in Ahafo Region in Ghana.

1.2 Purpose of the Study

The purpose of the study was to investigate the effect of inquiry-based teaching approach on Senior High Schools (SHS) students' achievement in circle theorems inthe Asutifi North District of Ghana.

1.3 Research Questions

The study was guided by the following research questions:

1) what are the causes of poor performance of students' in circle theorems?

2) what is the effect of using inquiry-based teaching approach on students' achievement in circle theorems?

1.4 Definition of Terms

In the context of this study, the following definitions of terms have been used basedon the objectives, scope, limitations and delimitations of the study.

Circle Theorems: it is one of the geometry topics in senior high school syllabus. It is known as plane geometry II. It can be found in unit 2.10 in 2010 core mathematics teaching syllabus.

Students' Achievement: Student achievement refers to the amount of academiccontent learned by a student within a specified amount of time. The achievement can be measured using various assessment tools such as achievement tests, observation or interview.

Traditional Method of Teaching: For the purpose of this study, the traditionalmethod of teaching mathematics is defined as the process by which mathematics teachers explain concepts to students by using board illustrations and then follow the explanations up with examples from textbooks.

2. Theoretical Framework

This study is anchored on constructivist theory. Constructivism is a theory about how we learn. It also suggests that children must be active participants in the development of their own understanding. Constructivist designers view instruction as "a process of supporting [knowledge] construction rather than communicating knowledge" (Cunningham & Duffy, 1996). The constructivist classroom is an environment where learners actively inquire and originate new knowledge and ideas through engaged dialogue, interaction, presentation, sharing, and negotiation. In this setup, teachers' role is to guide and moderate the discussion rather than passively passing information to the learners. Constructivist teachers provide direction to the learners by engaging them in inquiry activities and by stimulating student centered active discussion and knowledge sharing, i.e., promoting active learning in a social setup where learners construct new knowledge according to their prior knowledge, social realities, peers' perspectives, and new findings (Bruner, 1986). Again, constructivist teaching, emphasize that children have to build their own scientific knowledge and understanding. At each step-in science learning, they need to interpret new knowledgein the context of what they already understand. Rather than putting formed knowledge into children's minds, in the constructivist approach, teachers help children construct scientifically valid interpretations of the world and guide them in altering their scientific misconceptions (Martins, Sexton, Franklin & Gerlovich, 2005).

In constructivism, collaboration is emphasized (Adler, 1997) and this is in line with inquiry-based classroom which allows learners to collaboratively engage in decision making regarding the solution to a problem at hand with learners not losing their autonomy and control. In inquiry-based teaching approach, students experience the processes of knowledge creation and the key attribute is learning stimulated by an inquiry a student-centered approach, a more to self-directed learning and an active approach to learning (Spronken-Smith, 2007). The teacher's role in a constructivist classroom is to prompt and facilitate discussion, and to guide students by asking questions that will lead them to develop their own conclusions on a subject. If inquiry-based teaching approach is based on the belief that knowledge is generated through the process of students working and conversing together to tackle real-life problems and makes discoveries, then constructivism and inquiry-based teachingapproach are perfect match.

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

A number of factors have been put forward to explain why students perform poorly in geometry and circle. Findings made by Noraini (2006); Aysen (2012) have shown thatsome factors are identified to make the learning of geometry concepts in mathematics difficult which include: teachers' methods of instruction, geometric language, visualizing abilities. Fabiyi (2017) found out that the reasons given by students for perceiving geometry concepts difficult includes: unavailability of instructional materials, teachers' method of instruction and so on.

The quality of instruction is one of the greatest influences on the students' acquisition of geometry knowledge in Mathematics classes. According to Akyeampong, Lussier, Pryor, and Westbrook (2013), mathematics teachers in sub-Saharan Africa use the traditional method of teaching in their lessons where concepts are taught by giving a set of rules to students to be followed without the students knowing how those concepts came about. Traditional approaches in learning geometry emphasize moreon how much the students can remember and less on how well the students can think and reason. Thus, learning becomes forced and seldom brings satisfaction to the students (Baffoe & Mereku, 2010). The problem with traditional instruction is the concept of rote learning. Marshal (2006) took the definition of "rote" from the OxfordEnglish Dictionary as, a mechanical manner, by routine; especially by the mere exercise of memory without a proper understanding of, or reflection upon, the matter in question. Through traditional mathematics instruction, children are expected to use a mathematical concept before they have been able to experience it primarily focusing on how the teacher told them how to use it. This style of teaching is what Battista (2009) as cited by Marshal (2006) described as ineffective and seriously stunts the growth of students' reasoning and problem-solving skills.

2.2 Concept of Inquiry-Based Teaching Approach

Inquiry-based learning is a pedagogy which enables students experience the processes of knowledge creation and a more to self-directed learning and an active approach to learning (Spronken-Smith, 2007). Inquiry-based learning can also be defined as an approach to teaching and learning that places students' questions, ideas and observations at the centre of the learning experience (Friesen & Scott, 2013).

There are forms of inquiry that are commonly used in inquiry-based instruction. They are confirmation inquiry, structured inquiry, guided inquiry, and open inquiry (Pappas, 2014). The first level of inquiry is confirmation inquiry in which students are provided with the question and method as well as the results, which are known in advance (Pappas, 2014). The second level of inquiry learning is structured learning where the students are introduced to the experience of conducting investigations or practicing specific inquiry skills like those of collecting and analyzing data (Banchi & Bell, 2008). This is where the teacher mainly directs the inquiry by providing questions to be investigated and will then provide a step-by-step instruction to help students arrive at the answer. This kind of inquiry is important because it enables students to gradually develop their ability to conduct more open-ended inquiry. It is also good level to start for teachers who are new to inquiry-based teaching method (Banchi & Bell, 2008). The third level of inquiry is guided inquiry. It is the inquiry level where the question and procedure are provided by the teacher; however, the students arrive at an explanation supported by their investigations (Pappas, 2014). Here the teacher chooses the question and the students will take more responsibility for establishing the direction and methods of the inquiry. The teacher plays an important role in guided inquiry. This could be through feedbacks or posing further questions to help lead the students in the right direction (Banchi & Bell, 2008). The final level of inquiry learning is open inquiry. In free inquiry, students form their own questions, design their own methods of investigation, and carry out the inquiry process without guidance from the teacher (Pappas, 2014). In open inquiry, students take the lead in establishing the question and methods while the teacher takes on a supportive role. Having students to ask questions is key to open inquiry and requires a high order thinking. However, it is possible to use a combination of the types mentioned and it is called the coupled inquiry (Banchi & Bell, 2008).

The inquiry teaching style establishes itself as different from other constructivist guided approaches in the sense that it is not a minimally guided learning environment and that direct instruction can be used in the context of inquiry teaching and learning. Proper inquiry teaching approach requires that teachers carefully scaffold their students as they challenge them with new mathematical material (Hmelo-Silver et al., 2007). Once students are challenged, they are expected to engage in creating conjectures, analysing conjectures, communicating, working collaboratively, and engaging in mathematical argument (Stonewater, 2005).

2.3 Effect of Inquiry-Based Teaching Approach on Students' Achievement

For teachers to have a proper understanding of students' mathematical knowledge andknow-how, there must be tangible ways teachers can gain insight into their students' thought processes. Inquiry-based mathematics approach does just that (Ferguson, 2010). The teacher's role has evolved from concept deliverer to concept facilitator where questions are posed to get students thinking and experiencing the mathematical concepts at hand. Students are encouraged to "show what they mean" and "explain" their thinking either orally or in written form (Ferguson, 2010).

According to Ferguson (2010) the inquiry-based teaching approach has a positive effect on the mathematics achievement of students. In Ferguson (2010) study, two high school geometry classes were taught area formulation using a traditional lecture-based approach to instruction. A third geometry class was taught area formulation utilizing inquiry-based instructional methods. Students in both groups took both a pre- test and post-test. At the end of the exercise, Students involved in the inquiry-based lessons exhibited better retention, a better ability to problem solve, and better performance on decontextualized mathematical problems than their peers who were taught in the traditional fashion. He stated that, the inquiry-based mathematics instruction improves students' mathematics achievement. He therefore recommended that teachers of mathematics should apply the inquiry-based teaching and learning approach in both at the junior levels through to the tertiary levels.

A quasi-experimental study carried out by Riordan and Noyce (2001) compared two inquiry-based mathematics programmes; an elementary programme called Everyday Mathematics and a middle school programme entitled Connected Mathematics. The study compared state-wide standardized test scores for students using these curriculums to demographically similar students using a mix of traditional instruction methods. The results of this study showed that students in schools using either ofthese inquiry-based programmes as their primary mathematics curriculum performed significantly better on the 1999 state-wide mathematics test than did students in traditional programmes.

Similarly, Al-Qurashi (2002) conducted research on examining inquiry-based instruction in mathematics. Teachers were trained in professional development sessions and participated in an inquiry-based instruction project. He used videotapes, lesson plans of the participants, observations, and interviews to explore the implementation of inquiry-based instruction. Using the Engage, Explore, Explain, Elaborate and Evaluate inquiry-based design (5 E inquiry-based design), he developeda rubric to evaluate lessons. He concluded that inquiry-based instruction promoted student achievement.

2.4 Summary of Review

Findings from the review suggested that most students learn best when given problems to solve and that such problem-based learning improves retention and ownership of geometry (circle theorems) (Goos, 2004; Stonewater, 2005; Hmelo- Silver, Duncan & Chinn, 2007). Through the analysis of literature on inquiry-based approach it seems feasible that one could create a more optimal learning environment for most students. Few articles are dedicated to the detriments of inquiry instruction however, Lampert (1990) did indicate that not all students participate in inquiry environments. In particular, some students may not wish to participate in classroom discussions. Though there are concerns regarding inquiry-based instructional methods they are not severe enough that we should ignore the possible benefits of such an approach. In light of the current state of mathematics education, and the consideration that in current practice not all students are engaged in the learning processes, the inquiry-learning approach needed to be investigated. The possible benefits to students and mathematics education warrant a movement towards constructivist-based instruction and inquiry-based learning opportunities.

3. Method

3.1 Research Design

Mixed methods design was used for the study since both quantitative and qualitative data set was collected. Mixed methods design is based on the premise that a singledata set is not sufficient to answer all the research questions which are different in nature (Creswell, 2012). Not all, mixed method approach holds greater potential to address complex questions by acknowledging the dynamic interconnections that traditional research methods have not adequately addressed (Hesse-Biber, 2010).

The use of the quantitative approach enables the researcher to use the students' test data to ascertain if there was any positive or negative influenced of inquiry-based teaching approach on students' achievement in circle theory. This was done by the useof independent and dependent t-tests to test for statistical significance in the differences in pre and post test scores of the students. The qualitative approach on the other hand, allow the use of semi-structured interview data to get an in-depth knowledge of causes of poor performance of students in circle theory from students' and mathematics teachers' perspective. Qualitative approach also enables the researcher to use observation data collected from mathematics teachers on challenges associated with inquiry-based teaching approach in teaching circle theorem classroom.

Mixed method was used to collect different and complementary data on the same topic for integration and interpretation to address the overall content aim of the study (Creswell & Clark, 2011). This method is justified on the basis that the researcher collected both quantitative and qualitative data within the study period to address the aim of this study. The reason for combining both quantitative and qualitative data wasto bring together the strengths of both forms of data for this research work and better understanding of the results (Cohen, Manion & Morrison, 2007; Creswell, 2009).

3.2 Population

Field (2013) described population as an entire collection of things. Also, Nworgu (2006) classifies population as target and accessible where target population is all the members of a specific group to which the investigation is related while the accessible population is defined in terms of those elements in the group within the reach of the researcher. The target population for the study was all the third-year students and mathematics teachers in the public senior high schools in Asutifi North District in Ahafo Region of Ghana. There are two public senior high schools in the district with a total population of 657 students in third-year and 23 mathematics teachers these schools.

3.3 Sample and Sampling Technique

A sample according to Gerrish and Lacey (2010), is a subset of a target population, normally defined by the sampling process. The sample for the study consists of 105 students and 6 mathematics teachers selected from the two Senior High Schools in the District. Considering the purpose and the design of the study, the researcher employed simple random and convenience sampling techniques to select the sample from the population. Simple random sampling is a process of selecting a sample from a population in a way that every different possible sample of the desired size has the same chance of being selected (Devore, 2005). On the other hand, a convenience sampling is a type of non-probability sampling where members of target population that meet certain practical criteria such as easy accessibity, geographical proximity, availability at a given time, or the willingness to participate are included for the purpose of the study (Dornyei, 2007). Simple random sampling technique was use to select 105 students for the study. Simple random sampling was use to select two intactclasses, one from each school. This technique was used to avoid bias in selecting the classes. School "A" have seven classes for the programmes of General Arts, General Science and Home Economics and School "B" also have eight classes for the programmes of General Arts, General Science, Home Economics and Visual Arts. These classes were also coded according to each selected school. The coded numbers were also keyed into the random number generated calculator to select the classes to be used for this study. For school "A", 3F1 (3 General Arts 1) class was selected, the number students in 3F1 class was 53 and for school "B", 3E1A (3 Home economics, 2) class was selected with a total number of 52 students. Final year students were selected because they treated circle theorems in form 2 so they are the right studentsto provide vivid responses about their perception on circle theorems. Convenience sampling technique was used to select 6 mathematics teachers and 10 students to collect interview data from each group (control and experimental) school. The selection of both the mathematics teachers and students was done based on their availability and willingness to participate in the study at the time the interview was conducted.

3.4 Research Instruments

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

3.5 Circle Theorems Achievement Test (CTAT)

Circle Theorems Achievement Test was used as an instrument in collecting quantitative data to assess the effectiveness of the experiment on the experimental group. The researcher administered two tests (i.e., pre-test and post-test). These items were developed by the researcher based on the research questions and theoretical perspective. The content of the test items was taken from a Government approved students' textbooks that are commonly used in teaching geometry in all Senior High Schools (SHSs) in Ghana and all the items aligned with the objectives from the core mathematics teaching syllabus for SHSs in Ghana.

The pre-test consisted of 10 major items (see Appendix B). The pre-test was intended to measure students' level of attainment in the concept before treatment. It also helpedto unveil students' areas of difficulty in the concept in order to design a treatment that would best suit their level of attainment. The post-test contained the same number of items as the pre-test. The difficulty level of the post-test was similar to the pre-test. However, the items in the post-test were different from those in the pre-test (see Appendix C). According to Creswell (2012), using different test items on pre-test and post-test of a test instrument eliminates biasness from the scores. The post-test was intended to measure participants' attainment in circle theorem after the treatment has been implemented. Pre-test and post-test were administered to all the 105 students selected for the study, in both experimental group (52 students) and control group (53 students). The scores of both pre and post-tests was used to answer research question 2.

3.6 Semi-structured Interview

Semi-structured interviews have the advantage of generating qualitative data through the use of open-ended questions which allow the participants have in-depth conversation with the interviewer, choosing their own words. Such interviews have increased validity because it gives the interviewer the opportunity to probe for a deeper understanding, ask for clarification and allow the interviewee to steer the direction of the interview (McLeod, 2014). The researcher therefore used semi- structured interview to seek both students' and teachers' in-depth knowledge on the causes of poor performance of students in circle theorems.

The students' semi-structured interview guide contains 2 items, the first item with 1 sub-item which was developed by the researcher and it was administered to 10 conveniently selected students. 5 students from the experimental group and other 5 students from the control groups after the post-test (see Appendix D). The mathematics teachers' semi-structured interview guide also contains 2 items, the first item with 1 sub-item which was developed by the researcher and it was administered to 6 conveniently selected mathematic teachers. 3 mathematics teachers from each experimental and control group's school (see Appendix E). The interview was used to answer research question 1.

3.7 Observation

Observation is a systematic data collection approach in which the researchers use all their senses to examine people in natural setting or naturally occurring situations (Cohen & Crabtree, 2006). Two mathematics teachers were conveniently selected as observers for the study. The observers were always present in the experimental group class during the intervention period. The observers were directly observing the implementation of the intervention in each period and taking notes quietly on the challenges associate with the inquiry-based teaching approach in the classroom without interfering with the lessons based on the observation guide (see Appendix F). Observations made based on the observation guide was used to answer research question three.

3.8 Reliability

William (2006), was of the view that reliability is the consistency or dependability of the measurement; or the extent to which an instrument measures the same way each time it is used under the same condition with the same subjects. Moreover, Creswell and Clark (2017) stated that reliability implies scores received from participants should be consistent and stable over time when the instrument is repeatedly administered. Test-retest is one of the ways to conduct reliability test. Test-retest approach was employed by the researcher to examine the reliability of the CTAT in this study. According to Creswell (2012), the test-retest approach of measuring reliability involves administering the same test at two different times to the same participants at a considerable time interval. In this study, the researcher administered CTAT to one of the form 2 science class, 2A1 students of the control group school and after a month re-administered them to the same students again. The results were used for modification of instruments. The modified and improved instruments were then used in this study. The data collected was used to determine the reliability of the instruments. The correlation co-efficient of reliability of CTAT was calculated using Karl Pearson's co-efficient of correlation testing in SPSS. The correlation coefficients of reliability of CTAT was 0.82. The reliability coefficient was greater than 0.5, therefore, the CTAT was reliable for having high degrees of reliability and could help in achieving research objective for this study.

3.9 Validity

According to Field (2013), validity basically means measuring what you think you aremeasuring. Field (2013) stated that content validity was really the degree to which an item can be considered as a representative and Cohen, Manion and Morrison (2007) asserted that content validity is concern with how an instrument fairly and comprehensively covers the domains or items that it purports to cover as the face validity is where superficially the test appears at face value to test what it is designed to test. To attain content and face validity of the instruments, the researcher gave the instruments (interview guide, circle theorems achievement test and observation guide)to his Supervisor to examine after which all remarks, corrections and comments were made.

3.10 Data Collection Procedure

The researcher visited the sample selected Senior High Schools and discuss thepurpose of the study with the headmasters, and also seek their permission to carry out all exercises of the study that had to do with data collection and intervention.

3.11 Pre-intervention Stage

The researcher after seeking permission to carry out all exercises of the study in the selected sample schools and had the approval, went on and collected his first data on the schedule date. The circle theorems achievement test that is pre-test was administered to students in both schools on the same day. The researcher collected students work for marking (see Appendix H) and analysis of scores. Four days after the pre-test, researcher met the control and experimental group separately and explain the purpose of the interview to them. The researcher then granted one-on-one interviews to 10 students and 6 mathematics teachers selected from both the experimental and control groups, 5 students and 3 teachers from each group. Each interview took a minimum duration of 10 minutes and a maximum duration of 15 minutes. The researcher audiotaped the questions and responses of the interviews. The researcher used a total of two days to conduct the interviews.

3.11.1 Intervention

Lesson design

One of the goals of this study was to teach the same concept in two different ways using traditional, lecture-based instruction with the control group, and inquiry-based instructional methods with the experimental group. These lessons were to be taught over the same timeframe. The control group lessons were taught using the traditional approach described by Stonewater (2005) and Goos (2004) which involved reviewing the homework assignment from the previous day, followed by a presentation of new material, and concluded with a homework assignment. New material was presented using lecture-based instruction that included examples of problems that they would see in their homework, and the formulas required to solve these problems. Parts necessary for substitution into circle theorem formulas were highlighted, and examples included the various theorems. Experimental group lessons were inquiry-based and had specific objectives for each day to keep the experimental group on pace with the control group. Students in the experimental group solved the same type of circle theorem problems but were taught in a very different manner than the control group. Lessons were specifically designed practically to meet the criteria of inquiry-based learning environments and are included in Appendix G.

The inquiry lessons were facilitated through individual work and group work with the expectation that students would work with their group members to develop methods for solving problems related to circle theorem. As the instructor, I closely monitored the process of individuals and groups, and required all participants to give justification for their methods. I carefully designed the lessons to allow students to move from more simple environments for formulation into more complex problems that required usage of a developed method for solving circle theorem problems. Asthe class progressed into considering more complex theorems, students were expectedto draw on previous explorations to find solution to new problems. The lessons were designed to engage students in developing their own strategies for addressing problems on circle theorem, fitting with basic constructivist learning principles. At theend of each lesson, students were provided a problem set to take home and complete using their newly developed method. These problem sets were short (consisting oftwo to four problems) and only served to solidify developed understandings.

3.11.2 Procedure

At the beginning of the study, all members of the control group and the experimental group took a pre-test. The purpose of the pre-test was to measure students' prior knowledge about geometry and circle theorems problems. Data from the control group was compared with the experimental group using a t-test. Differences were noted and included in the final comparison of the two classes. Once the pre-test was completed, the differing lessons began. I, the researcher instructed the experimental class while a different mathematics teacher of the same experience took the class that represented the control group. Both of us were teaching the topic based on the lesson's objectives but different approaches.

The inquiry-based lessons were taught over a three weeks periods. Students were encouraged to discuss the circle theorems and develop methods through this discourse. Students' desks were arranged in groups of two or three to encourage group discussion. The researcher served as a facilitator of the discussion and guided the direction of the discourse in a way that helped students recognize the meaningful relationships underlying their mathematical tasks. This included small segments of direct instruction as well as extended periods monitoring students' progress as individual groups developed approaches. Researcher closely monitored individual groups' progress, aiding them in recognizing any noticeable misconceptions through question posing. Though direct instruction was sometimes used, it was never the primary method of instruction, and every class period began with student investigations and discussions of the circle theorems. Students were expected todefend their ideas in circle theorems to their groups as well as to the entire class, to support their abilities to explain circle theorems ideas. Students were not required to take formal notes. Instead, the hands-on materials and hand-outs that students received during lessons became their resource for future use. Daily lessons concluded with short take-home assignments to assess the students' developing understanding of the circle theorems.

The control group was taught using the government textbook for the selected school district. Their lessons followed those from the selected text and were supplemented with worksheets that are generally used in geometry classes to highlight specific concepts of circle theorems. Students were taught the formulas in circle theorems and were expected to use those formulas on a variety of problems, including problems that do not give all necessary information. All instruction was lecture-based and examples were provided to guide the students in using the circle theorems rules. Students were also shown the reasoning behind the formulations. Students were expected to participate in the lecture by answering questions and by taking formal notes, which were assessed for completeness at the end of the unit. To encourage participation and focus on the instructor throughout the class period, students' desks were placed in rows facing forward. Once instruction was completed, students were given an assignment out of the book and a small amount of class time to begin work so thatthey could ask questions if necessary. Work not completed during this time should have been taken home by the student for completion and inspect it next period. Students should have felt comfortable with this progression through the material, as this instructional approach had already been established throughout the school year.

Throughout the course of the study the researcher maintained a journal in which student behaviours within the experimental classrooms were documented, as well as the researcher's own reflections on what went well during the instructional periods. Researcher recorded examples of student conversations and strategies as they attempted onto use ideals of circle theorems they were learning. Through careful observation, researcher hoped to discover if the method of instruction impacted on the students' willingness to attack difficult problems on their own. Researcher was also trying to determine if the students in the experimental group adapted and took responsibility for their learning. When differences developed in their approaches to the mathematics and problem-solving approaches, then the researcher attempted to generalize these differences and included them in his observational data. Researcher also tried to find whether the experimental-group students performed better when confronted with a real-life situation involving circle theorem and circle geometry in general, observing whether they had a better-established ability to convey meaning and understanding through mathematical discourse to others. All of this information was important in determining the overall success of the instructional approach.

3.11.3 Post-intervention Stage

At the end of the three weeks intervention period, both groups of students were givena post-test. The post-test contained similar items as the pre-test. The post-test also contained a section of problems that required students to apply their problem-solving abilities. Such problems required more analysis on the part of the students and a betterunderstanding of the circle theorems relationships that exist among circle geometry and geometry as a whole. Students' post-test scripts were marked (see Appendix H) and analyzed the scores.

3.12 Data Analysis Procedure

The data obtained through the pre-test and post-test, semi-structured interview and observation guide were organized and summarized to obtain sense of information and to reflect on its overall meaning.

The data was analyzed quantitatively (descriptive and inferential data analysis) and qualitatively (descriptive words). The descriptive statistics such as measure of central tendencies and dispersion were used. According to Creswell (2012), descriptive statistics basically helps researchers to summarize the overall trends or tendencies in quantitative data, provides an understanding of the variability of the data and provides understanding of how one score compares with another. Thus, descriptive statistical analysis was used in an attempt to understand, interpret and describe the scores of experimental and control groups from the CTAT.

The inferential statistics, paired sample t-test and independent samples t-test were run to compare for any significant difference in the mean scores of the experimental and control groups at 95% confidence level was used to an to answer research question 1 quantitatively. Qualitative data generated from interviews and observations were used to answer research question 1 and 3 respectively. Recorded data generated from the one-on-one interviews were analyzed using thematic analysis. That is recorded audio from the interviews granted to participants were transcribed and analyzed based onthe topical areas contained in the interview guides. The researcher reported all events that emanated from the interviews by describing and interpreting the outcomes after reading the transcribed interview. The observations made by the mathematics teacherswere also compiled.

3.13 Ethical Consideration

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

4. Results and Discussions

4.1 Demographic Information of the Participants

The demographic information of students was described in detail in the following two tables. Table 1 presents the demographic background of the students according to their gender and Table 2 deals with their age group. This was necessary in order to understand the researcher's informants used for the study. A total of 105 final year students of the two senior high schools in the district participated in this study. This was made up of 29 males, representing 28% and 76 females, representing 72%. Oneof the two schools used for the study was mixed whilst the other was single sex (female) school. This contributed to the lower number of males as compared to the higher number of females. However, gender have no effect on the results of this study. This distribution is presented in Table 1.

Table 1. Gender Status of the Students

School	Class	Total number	Male	Female
A	3F1	53	29 (55%)	24 (45 %)
B	3E1A	52	0 (0%)	52 (100 %)
Total		**105**	**29 (28%)**	**76 (72 %)**

Source: Field data, 2020.

Table 2 shows the age distribution of the students. From Table 2, majority 77(73%) of the students were between 17-19 years, followed by 20(19%) of them were 20-22 years and only 8(8%) of them were between the ages of 14-16 years. This means that none of them was below 14 years and also above 22 years. Majority of the students are matured enough to give correct responses needed for the study.

4.2 Findings

The findings have been categorized and presented in three main themes in accordance with the research questions. These were the causes of poor performance of students in circle theorem, the effects of the inquiry-based teaching approach on students' achievement in circle theorems and challenges of inquiry-based teaching approach in teaching circle theorems.

4.2.1 Research Question 1

What are the causes of poor performance of students' in circle theorems?

Research question 1 sought to find out the causes of poor performance of students in circle theorem. In answering this research question, semi-structured interview was granted to 10 students and 6 mathematics teachers conveniently selected from both experimental and control schools.

The students' interview data were presented as follows.

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

Interviewee 1: *Hmmm, sir please no. I always score low marks. In fact myperformance is not good in that topic.*

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

Interviewee 1: *The way my teacher taught me, I did not understand it at all. The topicitself is something complex for me.*

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

Interviewee 1: *When the teacher was teaching us this topic, He allow us to write the properties or rules one by one as he was dictating. He then solve one example oneach properties and ask us to solve some from the textbook as class exercise. In fact I was confused about these properties. I didn't get anything that he taught us.*

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

Interviewee 1: *I suggest my teacher should take his time and teach us well, so that Ican also understand it well.*

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

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

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

Interviewee 2: *I find it difficult to apply more than two rules or properties to solve question. The rules or the properties are confusing to learn and understand and this makes it challenging to me.*

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

Interviewee 2: *I think my teacher should help me to know how to use more than two properties to solve problem.*

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

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

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

Interviewee 3: *I have idea or mind-set that circle theorems are complicated and difficult so I don't like solving problems on it. I know I will not select questions on the topic even in WASSCE. Thus why I score low marks.*

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

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

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

Interviewee 4: *No, please sir.*

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

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

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

Interviewee 4: *I suggest my teacher should have patience with those of us, slowlearners to understand the topic since he always move with the fast learners in class.* Interviewer: Do you score high marks in circle theorems exercise?

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

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

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

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

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

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

Interviewee 6: *No Sir,*

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

Interviewee 6: *The topic is too difficult for me, I don't get the understanding. It'sconfusing.*

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

Interviewee 6: *My teacher should make it easy for me by teaching it again.*

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

Interviewee 7: *No please sir,*

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

Interviewee 7: *The way my teacher taught me, I did not understand it. He was movingvery fast making everything difficult and confusing.*

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

Interviewee 7: *My teacher should take his time to teach it well for me to understand it. I think my teacher should teach it again.*

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

Interviewee 8: *No Sir,*

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

Interviewee 8: *I do not practice or solve problems on circle theorems and also thetopic is complicated and difficult to me.*

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

Interviewee 8: *I think I have to practice or solve problems on the topic by allowingfriends to teach me and change my mind set that topic is difficult.*

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

Interviewee 9: *No sir please.*

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

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

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

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

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

Interviewee 10: *No Sir*

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

Interviewee 9: *My perception about the topic is that it's difficult. It has many principles that makes it more difficult for me to understand and also my teacher madeit more difficult for me to understand.*

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

Interviewee 9: *My teacher should take his time and find proper way to teach the topicagain for me to understand*.

The mathematics teachers' interview data were also presented as follows.

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

Interviewee 1: *No sir please. Almost all my students performed poorly in circletheorem questions.*

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

Interviewee 1: *Most of my students' have in their mind that it is difficult topic andthey are lazy, they don't practice after classroom work.*

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

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

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

Interviewee 2: *No, their performance is not good in the topic.*

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

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

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

Interviewee 2: *I suggest teachers should help students to apply the basic principle in plane geometry 1 and how to use more than two circle properties solve a problem.*

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

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

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

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

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

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

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

Interviewee 4: *No sir*

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

Interviewee 4: *Students are lazy to practices on their own or in group. They are not serious about the topic. They claim it difficult to understand.*

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

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

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

Interviewee 5: *No*

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

Interviewee 5: *Students have ideal that circle theorems questions are complicated andconfusing for that reason they do not pay much attention on the topic.*

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

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

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

Interviewee 6: *No*

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

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

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

Interviewee 6: *Geometry at the junior high school level should be well strengthen in order to help students to apply geometry concepts at the senior high school level.*

4.2.2 Research Question 2

What is the effect of using inquiry-based teaching approach on students' achievement in circle theorems?

To determine the effectiveness of inquiry-base teaching approach on students' achievement in circle theorems, Circle Theorems Achievement Test (CTAT) was administered to students. All the 105 students selected from the two schools in the District agreed to participate in the study, wrote both the pre-test and the post-test of the CTAT. The summary of the scores of CTAT (pre and post) of the students is recorded in Table 2, Table 3, Table 4, Table 5, Table 6 and Table 7.

Table 2. Descriptive Statistics of Pre-test Scores of Control and Experimentalgroups

Groups	N	Minimum	Maximum	Mean	Std. Deviation
Experimental (B)	52	4.00	23.00	11.88	3.97
Control(A)	53	3.00	21.00	11.51	4.45

Source: Field data, 2020.

The pre-test scores of experimental and control groups were compared to determine if there exist any significant difference in the mean scores before treatment. In fact, the pre-test results revealed no significant difference between the two groups. The result from Table 2 showed a mean score of 11.88 for the experimental group as comparedto a mean score of 11.51 for the control group. The results indicated a mean difference of 0.37 between the mean scores of school "B" and "A" with respect to performance in the pre-test.

The following assumptions of independent sample t-test was checked and met (homogeneity of variance, the sample of each group was more than 30, samplesscores were normally distributed (see Appendix I) and two groups were randomly independent samples) before independent sample t-test was tested.

Table 3. Independent Samples T-test of Pre-test of Experimental and Controlgroups

Groups	N	Mean	Std. Div.	t-value	df	p-value
Experimental (B)	52	11.88	3.969	0.455	10 3	0.650
Control (A)	53	11.51	4.453			

Source: Field data, 2020.

To ascertain whether the difference between the mean scores was statistically significant, independent samples t-test was performed at 95% confidence level. The results of the independence samples t-test performed on the pre-test scores of school "B" and "A" is illustrated in Table 4. The results from the Table 4, the independent samples t-test performed on the pre-test scores of the two independent groups: that is experimental and control groups, revealed that there was no statistically significant difference between the experimental group and control group. (103)=0.455, p=0.650>0.05. This result indicates that both the experimental and control groups were at the same level in terms of conceptual understanding of the concept of circle theorems before the intervention was carried out.

The following assumptions of paired sample t-test were checked and met (homogeneity of variance, sample scores were normally distributed (see Appendix I) the sample of the group was more than 30 and the samples were randomly selected) before the paired sample t-test was tested.

Table 4. Paired Sample Statistics of Post and Pre-tests of the Experimental Groups

Groups	N	Minimum	Maximum	Mean	Std. Deviation	Std. Erro.Mean
Post-test	52	17	44	29.827	6.718	0.932
Pre-test	52	4	23	11.885	3.969	0.550

Source: Field data, 2020.

Table 5. Paired Sample T-tests of Post and Pre-tests of the Experimental Groups

Experimental(B)	N	Mean Difference	Std. Div.	t-value	df	p-value	Cohen's d
Post-test – Pre-test	52	17.942	4.578	28.263	51	0.000	3.92

Source: Field data, 2020.

To find out whether the difference in the pre-test and post-test scores of School "B" was statistically significant, paired samples t-test was conducted to compare the pre-test and post-test scores at 95% confidence interval. Tables 4 and 6 presents sample t-test of the Circle Theorems Achievement Test score of the experimental group. From Table 4, the mean and the standard deviation scores of the pre-test was (M=11.885 and SD=3.969) while that of post-test was (M=29.827 and SD=6.718). The results indicated a mean difference of 17.942 which was significant.

The results of the paired samples t-test (see Table 5) of participants from school B, the experimental group who were taught using inquiry-based teaching approach, indicated that there was statistically significant difference in their mean scores of the pre-test and the post-test, $t(51)$=28.263, p=0.000<0.05.

The effect size the inquiry-based treatment was calculated to determine the extent of the intervention (see Table 5). The effect size Cohen's d=3.92 which is large effect size was realized. This effect size value implies that the inquiry-based teaching approach has made a tremendous impact on students' concepts of circle theorems.

Research question 2 focused basically on the effectiveness of inquiry-based teaching approach on students' achievement on the concept of circle theorem in contrast to thetraditional instruction. The independent variable for the test was the teaching method (That is: the inquiry-based or the traditional method) and the dependent variable was the achievement inthe post-test of the two groups.

Table 6. Independent Sample Statistics of Post-test of Experimental and ControlGroups

Groups	N	Minimum	Maximum	Mean	Std. Deviation	Std. Error Mean
Experimental	52	17	44	29.83	6.718	0.932
Control	53	10	37	19.74	5.069	0.696

Source: Field data, 2020.

Table 7. Independent Samples T-test of Post-test of Experimental and ControlGroups

Groups	N	Mean	Std. Div.	t-value	df	p-value	Cohen's d
Experimental (B)	52	29.83	6.718	8.699	103	0.000	1.71
Control (A)	53	19.74	5.069				

Source: Field data, 2020.

The post-test scores of experimental and control groups were compared to determineif there exist any significant difference in the mean scores after treatment. In fact, the post-test results revealed significant difference between the two groups. The result from Table 6 showed a mean score of 29.83 and standard deviation of 6.718 for the experimental group as compared to a mean score of 19.74 and standard deviation of 5.069 for the control group. The results indicated a mean difference of 10.09 between the mean scores of school "B" and "A" with respect to performance in the post-test.

From Table 7, the results of the independent samples t-test revealed that there was statistically significant difference in mean between the experimental group and control group $t(103)$=8.699, p=0.00<0.05. This result suggests that the experimental group which was taught with inquiry-based teaching approach outperformed the control group taught with the traditional method.

The effect size the inquiry-based treatment was calculated to determine the extent of the intervention (see Table 7). The effect size Cohen's d=1.71 which is large effect size was noted. This effect size value signifies that the inquiry-based teaching approach has made a great impact on students' acquisition of circle theorems concepts.

4.3 Discussion of Results

This part of the study discusses the result of the study. The findings are discussed in view of previous related studies and the findings of the results of the research questions. The analysis of the interview data collected from both students and mathematics teachers show causes of poor performance of students' in circle theorems and suggested ways to improve upon their performance. Findings from the analysis of interview data revealed that students see circle theorems as the most difficult topic and developed negative attitudes towards circle theorems and this is one of the causes of their poor performance. These findings are consistent with findings of a research made by Mogari (1999) who found out that students with negative attitudes toward geometry have problems with understanding other concepts in geometry. Also, this findings is in line with the study made by Geddes and Fortunato (1993) who noted that students' attitudes about the value of learning geometry may be considered as both an input and outcome variable because their attitudes towards geometry can be related to educational achievement in ways that reinforce higher or lower performance. Similar, Pickens (2005) linked higher achievement in geometry to positive attitude on the part of the students. Findings reveals that, mathematics teachers teaching method also account for students' poor performance in circle theorem. These findings show that teachers use traditional method mostly to teach students' circle theorem which is line with the study made by Akyeampong, Lussier, Pryor, & Westbrook (2013) which confirm that mathematics teachers in sub-Saharan Africa use the traditional method of teaching in their lessons where concepts aretaught by giving a set of rules to students to be followed without the students knowing how those concepts came about. The finding also supports the statement This style of teaching is what Battista (2009) as cited by Marshal (2006) described as ineffective and seriously stunts the growth of students' reasoning and problem-solving skills. These findings also are in support with findings made by Keith (1999) who found out that the methods used in teaching Mathematics are instrumental in determining one's performance. Further findings show that the complex and abstract nature of geometry (Circle theorems) itself is also a cause of students' poor performance in the topic. Thisfinding agrees with the research finding made by Akinlade (2004) that geometry is oneof the topics among the abstract and complex aspects of mathematics that students find difficult to learn.

The finding from the independent samples t-test (see Table 3) analysis, p=0.650>0.05 showed that there was no statistically significant difference in the participants' achievement levels in plane geometry II (circle theorems) between the experimental group (school B) and the control group (school A) before the treatment was carried out. This indicated that both groups were on the same level of achievement before treatment. Findings from the paired samples t-tests (see Table 5) of participants from school B, the experimental group who were taught using inquiry-based teaching approach, indicated that there was statistically significant difference in their mean scores of the pre-test and the post-test, $t(51)=28.263$, $p=000<0.05$. The effect size of the intervention, Cohen's $d=3.92$ (see Table 6) was realized, which is large effect size. This effect size value implies that the inquiry-based teaching approach hasmade a tremendous impact on students' achievement in circle theorems.

Furthermore, the finding from the independent samples t-test (see Table 7) showed a statistically significant difference at $p=0.000<0.05$ between the achievement in the post-tests of participants who were exposed to inquiry-based teaching approach (Mean=29.83) in the experimental group and those exposed to the traditional approach (Mean=19.74) in the control group. The difference in means between both groups comparatively was an indicator to the result that the experimental group outperformed the control group in the post-test. The effect size Cohen's $d=1.71$ which is large effect size was noted (see Table 7). This effect size value signifies that the inquiry-based teaching approach has made a great impact on students' acquisition of circle theorems concepts. These findings revealed that when inquiry-based teachingapproach is employed, students' achievement is higher than when the traditional method is used. These findings strongly agrees with the studies by Riordan and Noyce (2001), Crawford and Snider (2000), Crawford and Snider (2000), Ferguson (2010), Mensah-Wonkyi and Adu (2016) and Abdi (2014) who in separate studies found students in the experimental group, who were exposed to lesson by enquiry-based teaching strategy, improved significantly in the post-test as compared to their counterparts in the control group taught by the traditional method. These results also support findings made by Al-Qurashi (2002) on examining inquiry-based instruction in mathematics and concluded that inquiry- based instruction promoted student achievement. The outcome of this study also confirm what Aktamis, Higde and Ozden(2016) found in their meta-analysis study that the inquiry-based learning method used in science education had much more significant effects on student achievement rather than on their science process skills and their attitudes towards science in contrast to the traditional teaching method. The results of this study agrees with theoretical framework of the study by Khalid and Azeem (2012) said constructivist approach modifies the role of the teacher to that of a facilitator who helps students to construct knowledge rather than to reproduce a series of facts which is the bases of inquiry- based teaching approach which promote students achievement.

Findings from the observation made by the mathematics teachers shows that some students don't fully engage themselves in the classroom activities in their various group work. Students also feel embarrassed when they answer questions wrongly. These findings are in conformity with what Gutierrez (2018) said that students with learning disabilities feel embarrassing and unwilling to participate in small group during inquiry-based learning. Inquiry-based teaching methods require more time dueto its practical and investigative nature. Students need to spend time to explore and find out the truth about each of the theories one after the other without learning them through "chew and pour". This finding agrees with the study conducted by Aulls (2002), who observed several teachers as they implemented inquiry-based activities intheir classrooms. He reported that the teacher whose students achieved all of their learning goals spent a great deal of time in instructional interactions with students by simultaneously teaching content and scaffolding-relevant procedures. The finding alsoagrees with Wei and Li (2017), said schooling and class time are limited, and students are not able to complete inquiry experiments in a short period of time. Outcome of theobservation also shows that class control and management was a bit challenging due to the fact that the classroom was not spacious and the class size was large. This finding is in line with study made by Harris and Rooks (2010) and Lawson (2000)who in separate studies found that teachers find it challenging to manage an inquiry classroom.

5. Major Findings

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

5.1 Research Question 1: What Are the Causes of Poor Performance of Students in Circle Theorems?

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

5.2 Research Question 2: What Is the Effect of Using Inquiry-based TeachingApproach on Students' Achievement in Circle Theorems?

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

5.3 Conclusions

Based on the findings from the study, it can be concluded that students' negative attitude and teachers' teaching methods are the main causes of students' poor performance in circle theorems. It can also be concluded that inquiry-based teaching approach increased students' conceptual understanding in circle theorems and hence increased students' achievement in circle theorems than the traditional instruction. Finally it can be concluded that forming smaller groups in class, control and management problem due to large class size and classroom not spacious and inadequate time factor are some of the challenges associated with the inquiry-based teaching approach

5.4 Recommendations

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

1) Mathematics teachers in senior high school level should use inquiry-based teaching approach to teach geometry (circle theorems) since it increases students' conceptual understanding and haven positive impact in their achievement in geometry (circle theorems).

2) Mathematics teachers should help students to changes their negative attitudes towards circle theorems (that it is difficult and confusing) and other geometry topics in order to sustain their interest in the topic.

References

Abdi, A. (2014). The effect of inquiry-based learning method on students' academic achievement in science course. *Universal Journal of Educational Research*, *2*(1), 37-41. https://doi.org/10.13189/ujer.2014.020104

Abreh, M. K., Owusu, K. A., & Ameadahe, F. K. (2018). Trends in performance of WASSCE candidates in science and mathematics in Ghana: Perceived contributing factors and the way forward. *Journal of Education*, *198*(1), 113-123. https://doi.org/10.1177/0022057418800950

Adegun, I. K., & Adegun, B. O. (2013). Students and teachers' views of difficult areas in mathematics syllabus: Basic requirements for Science and Engineering Education. *Journal of Education and Practice*, *4*(12), 235-243.

Adler, J. (1997). A Participatory-Inquiry and the mediation of mathematical knowledge in a multilingual classroom. *Educational Studies in Mathematics*, *33*(1), 235-258. https://doi.org/10.1023/A:1002976114883

Ahmed, E. (2005). *Identification of the problems of the low achievers in the subject of Mathematics at secondary level* (Un-published Thesis). IER, Lahore: University of the Punjab.

Aiken, L. R. (1990). Assessing the relationship between attitude toward mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education*, *28*(1), 26-47. https://doi.org/10.2307/749662

Akinlade, C. R. (2004). *Mathematics topic that students find it difficult to learn*.

Aktamis, H., Higde, E., & Ozden, B. (2016). Effects of the Inquiry-Based Learning Method on Students' Achievement, Science Process Skills and Attitudes towards Science. *Journal of Turkish Science Education*, *13*(4), 248-261.

Akyeampong, K., Lussier, K., Pryor, J., & Westbrook, J. (2013). Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? *International Journal of Educational Development*, 272-282. https://doi.org/10.1016/j.ijedudev.2012.09.006

Al-ebous, T. (2016). Effect of the Van Hiele Model in Geometric Concepts Acquisition: The Attitudes towards Geometry and Learning Transfer Effect of the First Three Grades Students in Jordan. *International Education Studies*, *9*(4), 87-98. https://doi.org/10.5539/ies.v9n4p87

Al-Qurashi, F. (2002). *An investigation of the role of inquiry-based instruction in mathematics teacher professional development activities and outcomes of an inquiry-based instruction project*. (UMI No. 3062143)

Alsup, J. K. (2003). A comparison of traditional and reform mathematics curricula in an eighth-grade classroom. *Education*, *123*, 689.

Arem, C. A. (2010). *Conquering math anxiety*. Brooks/Cole Cengage Learning.

Asante, K. O. (2012). Secondary students' attitudes towards mathematics. *IFE Psychologia: An International Journal*, *20*(1), 121-133.

Asiedu-Addo, S. K., & Yidana I. (2000). *Mathematics teachers' knowledge of the subject*.

Aulls, M. W. (2002). The contributions of co-occurring forms of classroom discourse and academica activities to curriculum events and instruction. *Journal of Educational Psychology*, *94*, 520-538. https://doi.org/10.1037/0022-0663.94.3.520

Awanta, E. K. (2004). Helping students overcome mathematics anxiety. *Mathematics Connection*, *4*(1), 39-43. https://doi.org/10.4314/mc.v4i1.21499

Ayot, H. O., & Patel, M. M. (1992). *Instructional methods*. Nairobi: Educational Research and Publications LTD.

Aysen, O. (2012). Misconceptions in geometry and suggested solutions for seventh grade students. *International Journal of New Trends in Arts, Sports and Science Education*, *1*(4). 1-13.

Baffoe, E., & Mereku, D. K. (2010). The Van Hiele levels of understanding ofstudents entering senior high school in Ghana. *African Journal of Educational Studies in Mathematics and Science*, *8*, 51-61. https://doi.org/10.4314/ajesms.v8i1.69103

Baker, W., Barstack, R., Clark, D., Hull, E., Goodman, B., Kook, J., Kraft, K., Ramakrishna, P., Roberts, E., Shaw, J., Weaver, D., & Lang, M. (2008). Writing-to-learn in the inquiry-science classroom: Effective strategies from middle school science and writing teachers. *Clearing House*, *81*(3), 105-108. https://doi.org/10.3200/TCHS.81.3.105-108

Banchi, H., & Bell, R. (2008). The many level of inquiry. *Science and Children*, *46*(2), 26-29. Retrieved from http://login.pallas2.tcl.sc.edu/login?

Barell, J. (2007). *Problem based learning and inquiry approach*. New Delhi: Sage Publications India Pvt. Ltd.

Battista, M. (2009). Highlights of research on learning school geometry. In T. V. Craine, & R. Rubenstein (Eds.), *Understanding Geometry for a Changing World: Seventy-first Yearbook (*pp. 91-108). Reston VA the National Council of Teachers of Mathematics (NCTM).

Battista, M. T. (2007). Geometry results from the Third International Mathematics and Science study. *Teaching Children Mathematics*, *5*(6), 367-373. https://doi.org/10.5951/TCM.5.6.0367

Behlol, G. (2009). *Development and validation of module in English at secondary level in Pakistan* (Unpublished PhD thesis). Islamabad: International Islamic University. https://doi.org/10.30971/pje.v26i2.168

Betiku, O. F. (2001). *Causes of mass failure in Mathematics examinations among students*. A commissioned paper presented at Government Bloom (1986) Secondary school, Karu, Abuja science day, 1st March.

Booker, G. (1992). *Constructing mathematical conventions formed by the abstraction and generalization of earlier ideas: The development of initial fraction ideas*. Paper presented at the Seventh International Congress on Mathematical Education (ICME-7), University Laval, Quebec City, Quebec, and Canada.

Bruce, D. (2016). Mathematics anxiety among Ghanaian students: A case study of students of Kinbu Senior High/Technical School, Accra and Hermann-Gmeiner SOS Junior High School, Tema. *Journal of Education and Practice*, *7*(15), 75-83.

Bruner, J. (1986). *Actual minds, possible worlds*. Cambridge, Mass.: Harvard University Press. https://doi.org/10.4159/9780674029019

Burns, M. (2004). Writing in math. *Educational Leadership*, *62*, 30-33.

Burton, D. M. (1999). *The history of mathematics: An introduction* (4th ed.). Boston: WCB McGraw-Hill.

Canada, D., & Blair, S. (2006). Intersections of a circle and a square: An investigation. *The Mathematics Teacher*, *100*(5), 324-328. https://doi.org/10.5951/MT.100.5.0324

Cangelosi. (2003). Quoted by national science foundation. *Applications and Applied Mathematics (AAM): An International Journal*, *1*(1), 62-82.

Chappell, M. F. (2003). Keeping Mathematics front and Centre, Reaction to middle grades Curriculum Projects Research 285-298 Mahwah. *Erlbaun associates*.

Charles, B., & Lynwood, W. (1990). *The teaching of secondary Mathematics* (4th ed.).

Chen, B., & Wei, B. (2015). Investigating the factors that influence chemistry teachers' use of curriculum materials: The case of China. *Science Education International*, *26*(2), 195-216.

Cheng, V. M. (2004). *Progress from traditional to creativity education in Chinese society*. Singapore: World Scientific Publishing. https://doi.org/10.1142/9789812567192_0007

Cheng, V. M. (2010). Teaching creative thinking in regular science lessons: Potentialsand obstacles of three different approaches in an Asian context. *Asia-Pacific Forum on Science Learning and Teaching*, *11*(1), 1-21.

Clement, D. (2003). Teaching and learning geometry. In J. Kilpatrick, W. Martin, & D. Schifter, (Eds.), *A research companion to principles and standards forschool mathematics*. Reston, VA: NCTM.

Clements, D. H., & Battista, M. T. (1992). *Geometry and spatial reasoning handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 420-464). New York, NY, England:Macmillan Publishing Co, Inc.

Clements, D. H., & Sarama, J. (2000). The earliest geometry. *Teaching Children Mathematics*, *7*(2), 82-84. https://doi.org/10.5951/TCM.7.2.0082

Cobb, P. (1988). The tension between theories of learning and instruction in mathematics education. *Educational Psychologist*, *23*(2), 87-103. https://doi.org/10.1207/s15326985ep2302_2

Cockroft, W. H. (1982). *Report of the committee of inquiry into the teaching ofMathematics in schools*. London: HMSO.

Cohen, D., & Crabtree, B. (2006). *Qualitative research guidelines project*. Retrieved from http://qualres.org/HomeObse-3594.html

Cohen, L., Manion, L., & Morrison, K. (2007). *Research method in education*. NewYork: Taylor & Francis e-Library. https://doi.org/10.4324/9780203029053

Crawford, D. B., & Snider, E. (2000). Effective mathematics instruction: The importance of curriculum. *Education and Treatment of Children*, *23*, 122-142.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative and mixed methodsapproaches* (3rd ed.). London: Sage Publications.

Creswell, J. W. (2012). *Educational research: Planning, conducting and evaluating quantitative and qualitative research* (4th ed.). Boston, MA: PearsonEducation, Inc.

Creswell, J. W., & Clark, P. V. (2011). *Designing and conducting mixed methodsresearch* (2nd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methodsresearch*. Sage Publications.

Crowley, M. L. (1987). The van Hiele model of the development of geometric thought. In M. M. Lindquist (Ed.), *Learning and teaching geometry, K-12* (Vol. 1987, Yearbook, pp. 6-13). Reston Virginia: The National Council of Teachers of Mathematics.

Cunningham, D., & Duffy, T. (1996). Constructivism: Implications for the design and delivery of instruction. *Handbook of research for educational communicationsand technology* (pp. 170-198). New York: Simon & Schuster Macmillan.

Davidson, N. (1990). *Cooperative learning in mathematics: Handbook for teachers*. Menlo Park, California: Addison-Wesley Publishing Company.

Devore. (2005). *Statistics-The exploration and analysis of data*. USA: Thomson Learning Inc.

Dornyei, Z. (2007). *Research methods in applied linguistics*. New York: OxfordUniversity Press.

Draper, R. (2002). School mathematics reform, constructivism, and literacy: A case for literacy instruction in the reform-oriented math classroom. *Journal ofAdolescent & Adult Literacy*, *45*(6), 520.

Drickey, N. (2001). *A comparison of virtual and physical manipulatives in teaching visualization and spatial reasoning to middle school mathematics students*. Retrieved from Dissertation Abstracts International http://www.lib.umi

Driscoll, M., Dimatteo, R. W., Nikula, J., & Egan, M. (2007). *Fostering geometric thinking: A guide for teachers, Grade 5-10*. Portsmouth, NH: Heinemann.

Duatepe, A. (2000). Best practices for teaching mathematics to secondary students with special needs. *Focus on Exceptional Children*, *32*. https://doi.org/10.17161/foec.v32i5.6919

Engle, P., Grantham-McGregor, S., Black, M., Walker, S., & Wachs, T. (2007). How to avoid the loss of potential in over 200 million young children in the developing world. *Child Health and Education*, *1*(2), 15.

Ernest, P. (1996). Varieties of constructivism: A framework for comparison. In G. A. Golding (Ed.), *Theories of mathematical learning* (Vol. Working Group 4 (WG4) Theories of learning mathematics, pp. 335-351). New York: Routledge.

Fabiyi, T. R. (2017). Geometry concepts in Mathematics perceived difficult to learn by Senior High School students. *IOSR Journal of Research & Method in Education*, *7*(1), 84-90. https://doi.org/10.9790/7388-0701018390

Farrant, S. J. (1997). *Principles and practice of education*. Essex: Singapore: Longman Publishers.

Ferguson, K. (2010). *Inquiry based mathematics instruction versus traditional mathematics instruction: The effect on student understanding and comprehension in an eighth grade pre-algebra classroom*. Cedarville: Cedarville University. https://doi.org/10.15385/tmed.2010.5

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage Publications.

Friesen, S., & Scott, D. (2013). *Inquiry-based learning: A review of the research literature*. Alberta: Alberta Ministry of Education.

Fuys, D., Geddes, D., & Tischler, R. (1988). The van Hiele model of thinking in geometry among adolescents [Research work on adolescents]. *Journal for Research in Mathematics Education* (Monograph # 3), 4-71. https://doi.org/10.2307/749957

Geddes, D., & Fortunato, I. (1993). Geometry: Research and classroom activities. In D. T. Owens (Ed.), *Research ideas for the classroom: Middle gradesmathematics* (pp. 199-225). New York: Macmillan Publishing.

Gerrish, K., & Lacey, A. (2010). *The research process in nursing* (6th ed., pp. 455-472). Wiley-Blackwell, Oxford.

González, G., & DeJarnette, A. F. (2013). Geometric reasoning about a circle problem. *Mathematics Teacher*, *106*(8), 586-591. https://doi.org/10.5951/mathteacher.106.8.0586

Goos, M. (2004). Learning mathematics in a classroom community of inquiry. *Journal for Research in Mathematics Education*, *35*(4), 258-291. https://doi.org/10.2307/30034810

Gutierrez, D. (2018). *Pro and cons of inquiry base learning for college success*. Stanford University.

Haghighi, A. M., Vakil, R., & Weitba, J. K. (2005). Reverse-traditional/hands-on: An alternative method of teaching statistics. *Application and Applied Mathematics(AAM.)*, *1*.

Halat, E. (2008). In-service middle and high school mathematics teachers: Geometric reasoning stages and gender. *The Mathematics Educator*, *18*(1), 8-14.

Harris, C., & Rooks, D. (2010). Managing inquiry based science: Challenges in enacting complex science instruction in elementary and middle school classroom. *Journal of Science Teachers Education*, *21*(2), 227-240. Retrieved May 26, 2011, from Ebscohost database. https://doi.org/10.1007/s10972-009-9172-5

Hesse-Biber, S. N. (2010). *Mixed methods research: Merging theory with practice*. Guilford Press

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, *42* (2), 99-107. https://doi.org/10.1080/00461520701263368

Hodge, L. (2008). Student roles and mathematical competence in two contrasting elementary classes. *Mathematics Education Research Journal*, *20*(1), 32-50. https://doi.org/10.1007/BF03217468

Horn, L. R. (1995). *Classroom learning & teaching*. NY: Longman Publisher. Reading, Mass: Addison-Wesley publishing company

Ibadan: University Press Ltd.

Idris, N. (2006). *Teaching and learning of mathematics: Making sense and developingcognitive ability*. Kuala Lumpur: Utusan Publication and Distributors.

Ismail, J. (2008). *The effects of a reform curriculum on students' problem solving abilities* (Unpublished master's thesis). Boise State University, Boise, ID.

Jones, K., & Bills, C. (1998). *Visualization, imagery, and the development of geometrical reasoning*. Paper presented at the British Society for Research into Learning Mathematics, University of Birmingham, UK.

Jones, K., Fujita, T., & Ding, L. (2006). *Informing the pedagogy for geometry:Learning from teaching approaches in China and Japan*. Paper presented atthe Proceedings of the British Society for research into Learning Mathematics.

Kalhotra, S. K. (2013). A study of causes of failure in mathematics at high school stage. *Academic Research International*, *4*(5), 588-599.

Kausar, R., & Zaheer, S. (2008). *Analysis of grade 4 students' performance in mathematics* (Un-published thesis). IER, Lahore: University of the Punjab.

Keith, J. (1999). *Planning for mathematic learning in Johnston-Wilder, S. (Eds.), learning to teach Mathematics in secondary schools*. London and New York; Rout ledge.

Khalid, A., & Azeem, M. (2012). Constructivist VS traditional: Effective instructional approach in teacher education. *International Journal of Humanities and SocialScience*, *2*(5), 170-177.

Kim, M., & Tan, A. L. (2013). Rethinking difficulties of teaching inquiry-based practical work: Stories from elementary pre-service teachers. *InternationalJournal of Science Education*, *33*(4), 465-486. https://doi.org/10.1080/09500691003639913

Kiminza, O. (1999). *National study of science and mathematics in primary andsecondary schools in Kenya*. Nairobi: KIE.

Kinyua, M., Maina, L., & Odera, J. (2003). *Advancing in mathematics teachers' guideform 2*. Nairobi: Longhorn publishers Ltd.

Knight, K. C. (2006). *An investigation into the change in the Van Hiele levels of understanding geometry of pre-service elementary and secondary mathematicsteachers* (Doctoral dissertation). The University of Maine.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal*, *27*(1), 29-63. https://doi.org/10.3102/00028312027001029

Lawson, L. E. (2000). Managing the inquiry classroom: Problems and solutions. *The American Biology Teacher*, *62*(9), 641-648. Retrieved June 10, 2010, from Ebschost database. https://doi.org/10.2307/4451002

Lemlech, J. K. (1998). *Curriculum and instruction methods for elementary and middle school*. Upper Saddle River: Prentice-Hall, Inc.

Levasseur, K., & Cuoco, A. (2003). Mathematical habits of mind. In H. L. Schoen (Ed.), *Teaching mathematics through problem solving* (pp. 27-37). Reston: The National Council of Teachers of Mathematics Inc.

Li, J. J. (2015). *Research on the inquiry teaching of mathematics in high grade of primary school-A case of Shijazhuang city elementary school* (Master's Thesis). Hebei Normal University.

Lie, K. M., & Hafizah, H. (2008). Malaysian students' achievement in solid geometry. *Recent Researches in Education*, 141-147.

Longo, C. (2010). Fostering creativity or teaching to the test? Implications of state testing on the delivery of science instruction. *The Clearing House*, *83*(2), 54-57. https://doi.org/10.1080/00098650903505399

Mammana, C., & Villani, V. (1998). Geometry and geometry-teaching through the ages. *NEW ICMI STUDIES SERIES*, *5*, 1-3. https://doi.org/10.1007/978-94-011-5226-6_1

Marcus, R., & Fey, J. T. (2003). Selecting quality tasks for problem-based teaching. In H. L. Schoen (Ed.), *Teaching mathematics through problem solving* (pp. 55-67). Reston: The National Council of Teachers of Mathematics, Inc.

Marshal, J. (2006). Math wars 2: It's the teaching, stupid! *Phi Delta Kappan*, *87*, 356-363. https://doi.org/10.1177/003172170608700506

Martins, R. C., Sexton, Franklin, T. J., & Gerlovich. (2005). *Teaching Science for All Children: An Inquiry Approach* (4th ed.). Allyn & Bacon.

Mayberry, J. (1983). The van Hiele levels of geometric thought in undergraduate pre- service teachers. *Journal for Research in Mathematics Education*, *14*, 58-69. https://doi.org/10.2307/748797

Mayer, R. E. (1992). *Thinking problem solving and cognition* (2nd ed.). NY; Preeman press.

McLeod, S. (2014). *Simply psychology*. Retrieved from Simply Psychology website: www.simplypsychology.org/interviews.html

Mensah-Wonkyi, T., & Adu, E. (2016). Effect of the inquiry-based teaching approach on students' understanding of circle theorems in plane geometry. *African Journal of Educational Studies in Mathematics and Sciences*, *12*, 61-74.

Mereku, D. K. (2010). Five decades of school mathematics in Ghana. *Mathematics Connections*, *9*(8), 73-86. https://doi.org/10.4314/mc.v9i1.61558

Mestre, J. (1989). *Hispanic and Anglo students' misconceptions in mathematics*. Retrieved from ERIC Digests website: http://www.ericdigests.org/pre- 9213/hispanic.htm

Michalopoulou, A. (2014). Inquiry-based learning through the creative thinking and expression in early years education. *Creative Education*, *5*(6), 377. https://doi.org/10.4236/ce.2014.56047

Ministry of Education. (2010). *National syllabus for senior high school mathematics*. Accra: Ministry of Education.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry- based science instruction-What is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching*, *47*(4), 474-496. https://doi.org/10.1002/tea.20347

Mogari, D. (1999). Attitude and achievement in Euclidean geometry. *Proceedings of the International Conference on Mathematics Education into the 21st Century, Cairo*. New York: Macmillan Publishing. NCTM (2000). Principles and Standards for School Mathematics. Reston: NCTM.

Morris, R. V. (2001). Drama and authentic assessment in a social study classroom. *Journal of Social Studies*, *92*(1), 41-45. https://doi.org/10.1080/00377990109603974

Mulwa, E. C. (2014). The role of the language of mathematics in students' understanding of number concepts in Eldoret Municipality, Kenya. *International Journal of Humanities and Social Science*, *4*(3), 264-274.

Muschla, J. A., & Muschla, G. R. (2000). *Geometry teacher's activities kit: Ready-to-use lessons & worksheets for grades 6-12*. Jossey-Bass.

National Board for Professional Teaching Standards. (2009). *Profiles in excellence*. Chicago, Illinois.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (2003). *Principles and standards for school Mathematics*. Reston, V. A: NCTM.

NCTM. (2009). *Guiding principles for mathematics curriculum and assessment*. Retrieved October 14, 2009, from National Council for Teachers of Mathematics: http://www.nctm.org/standards/content.aspx?id=23273

Ndinda, M. D. (2016). *An analysis of the factors influencing achievement in mathematics geometry among secondary school students in Makadara sub- county, Nairobi County* (Doctoral dissertation). Kenyatta University.

Neel-Romine, L. E., Paul, S., & Shafer, K. G. (2012). Get to know a circle. *Mathematics Teaching in the Middle School*, *18*(4), 222-227. https://doi.org/10.5951/mathteacmiddscho.18.4.0222

Noraini, I. (2006). *Teaching and learning of mathematics: Making sense and developing cognitive abilities*. Perak: Utusan Publication Sdn. Bhd. Nigeria.

Nworgu, B. G. (2006). Educational research: Basic issues and methodology. *Nsukka: University Trust Publishers*, 45-49.

Olatoye, R. A., & Agbatogun, A. O. (2009). Parental involvement as a correlate of pupils' achievement in mathematics and science in Ogun State, Nigeria. *Educational Research and Reviews*, *4*(10), 457.

Pappas, C. (2014). *Instructional design models and theories: Inquiry-based learning model*.

Parr, R. (2007). Improving science instruction through effective group interactions. *Science Scope*, 21-23. Retrieved June 10, 2010, from Ebschost database.

Pesek, D. D., & Kirshner, D. (2000). Interference of instrumental instruction insubsequent relational learning. *Journal for Research in Mathematics Education*, *31*(5), 524-540. https://doi.org/10.2307/749885

Pickens, J. (2005). Attitudes and perceptions. *Organizational Behaviour in Health Care*, *4*(7), 43-76.

Polit, D. F., & Hungler, B. P. (1999). *Nursing research: Principles and methods* (6th ed.). Philadelphia: J. B. Lippincot.

Rafiq, M. T., & Ansari, Z. (2012). *Mathematics-7*. Lahore: Punjab Text Book board.

Rao, D. (2001). *Science education in developing countries* (pp. 124-126). New Delhi; Discovery Publishing House.

Riordan, J. E., & Noyce, P. E. (2001). The impact of two standards based mathematics curricula on student achievement in Massachusetts. *Journal for Research in Mathematics Education*, *32*, 368-398. https://doi.org/10.2307/749700

Rose, C. M., & Arline, C. B. (2009). *Uncovering student thinking in mathematics, Grades 6-12: 30 Formative Assessment probes for the Secondary Classroom*. USA: Corwin Press.

Rukangu, S. M. (2000). *Pupils' development of spatial ability in Mathematics: An issue of learning environment in selected secondary schools in Kenya. Nairobi* (Unpublished Ph.D thesis). Kenyatta University, Kenya.

Sa'ad, T. U., Adamu, A., & Sadiq, A. M. (2014). The causes of poor performance in mathematics among public senior secondary school students in Azare Metropolis of Bauchi State, Nigeria. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *4*(6), 32-40. https://doi.org/10.9790/7388-04633240

Santrock, J. W. (2001). *Educational psychology*. United States of America: McGraw- Hill Companies, Inc.

Scopes, P. G. (1973). *Mathematics in secondary schools: A teaching approach*. London: Cambridge University Press.

Sdrolias, K. A., & Triandafillidis, T. A. (2008). The transition to secondary school geometry: Can there be a “chain of school mathematics”? *Educational Studies in Mathematics*, *67*(2), 159-169. https://doi.org/10.1007/s10649-007-9093-1

Singh, M. (2004). *Modern teaching of mathematics*. New Delhi: Anmol publications PVT. LTD.

Slavin, R. E. (2006). *Educational psychology: Theory and practice* (8th ed.). Boston: Pearson Education, Inc.

Sofowora, S. O. (2014). *Anxiety and lack of motivation as factors affecting success rates in bridging mathematics* (Doctoral dissertation). University of South Africa, South Africa.

Sproken-Smith, R. (2007). Experiencing the process of knowledge creation: The nature and use of inquiry-based learning in higher education. *Journal ofEducational Research*.

Stonewater, J. K. (2005). *Inquiry teaching and learning: the best maths class inquiry teaching and learning: The best maths class study*. Chicago: School Science and Mathematics. https://doi.org/10.1111/j.1949-8594.2005.tb18034.x

Telima, A. (2011). Problems of teaching and learning of geometry in secondaryschools in River State, Nigeria. *International Journal of Emerging Science*, *1*(2), 143-152.

Uys, H. H. M., & Basson, A. A. (1991). Research methodology in nursing. *Pretoria: Haum* (pp. 59-80).

Wartonic, D. (2005). *A comprehensive assessment of CMP (Connected Math Program): Deficiencies leading to supplementation that meets key traditional educational needs* (Unpublished Master’s Thesis). Cambridge College,Cambridge, Massachusetts.

Weber, E. (2006). *Brain based business*. Retrieved December 23, 2007, from http://brainbasedbusiness.com

Wei, B., & Li, X. (2017). Exploring science teachers’ perceptions of experimentation: implications for restructuring school practical work. *International Journal of Science Education*, *39*(13), 1775-1794. https://doi.org/10.1080/09500693.2017.1351650

West African Examinations Council. (2006). West African Senior School Certificate Examination. In *Chief Examiner’s Report*. Accra: West African Examinations Council.

West African Examinations Council. (2017). West African Senior School Certificate Examination. In *Chief Examiner’s Report*. Accra: West African Examinations Council.

Wiggins, G. (2016). *Conceptual understanding in mathematics*. Retrieved from https://grantwiggins.wordpress.com/2014/04/23/conceptual-understanding- inmathematics/

Wiggins, G., & McTighe, J. (2008). Put understanding first. *Educational Leadership*, *65*(8), 36-41.

William, M. K. (2006). *The Research Methods Knowledge Base*. Cornell University. Retrieved on July 12, 2017 from http://www.socialresearchmethods.net/kb/order.htm

Wood, W. B., & Gentile, J. M. (2003). Teaching in a research context. *Science*, *30*(2), 15-10. https://doi.org/10.1126/science.1091803

Wu, Z. (2003). The discussion of difficulties and solution in inquiry-based scienceclasses. *Yan Jiu Xue Xi Zhuan Ti*, *35*.

Xue, H. N., & Chen, X. (2012). A national survey on the quality of present teachertraining programs. *Educational Science*, *28*(6), 53.