UNIVERSITY OF CAPE COAST

EXPERIMENTAL STUDY ON THE EFFECTIVENESS OF ACTIVITY-BASED TEACHING METHOD ON STUDENTS' ACHIEVEMENT IN PLANE GEOMETRY

KURI ALPHA

2023

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BY

KURI ALPHA

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

November 2023

DECLARATION

Candidate's Declaration

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

Candidate's Signature…………………… Date ………………….

Name: Kuri Alpha

Supervisor's Declaration

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

Supervisor's Signature………………….. Date………………….

Name: Prof. Douglas Darko Agyei

ABSTRACT

Failure rate in mathematics has become a topical issue in the larger society because of the importance of the subject to humanity. As a result, researchers and educationists are particularly interested in methods of teaching which improve students' performance in the subject. Using the concurrent embedded design mainly through achievement tests, focus group discussion, questionnaires and observation, this study was purported to explore the effectiveness of the activity-based teaching method on students' achievement in plane geometry. Eighty-four Senior High School (SHS) form two students from two intact classes in two different purposively selected Category A schools participated in this study with one class assigned as experimental group and the other the control group. Findings of this study revealed that the two teaching approaches both had positive effect on the achievement of students. The experimental group however outperformed their counterparts of the control group. Male students of the experimental group also outperformed and showed a more positive perception towards the activity-based approach of teaching and learning than their female counterparts. Responses of both sexes revealed that the activity-based approach used was interesting, helped in sharing ideas and facilitated easy understanding of the concepts of plane geometry. It was recommended that the activity-based approach should be used in teaching and learning in this domain of mathematics.

ACKNOWLEDGEMENTS

I would like to thank my supervisor Prof. Douglas Darko Agyei for his love and support. His professional expertise and guidance provided during this thesis work was irreplaceable. The Senior High School authorities who participated and supported the study equally deserve my thanks. Special thanks go to my brother Yakubu Kaayi (PhD) and Mr. Obeng Solomon my dearest friend for been there for me throughout the period of the thesis work. I appreciate also the time and effort of all the students who participated in the study.

DEDICATION

To my former headmaster: Mr Osumanu Namba

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CHAPTER ONE

INTRODUCTION

The relevance of mathematics in society at large cannot be derided. The development in all spheres of life hinges strongly on good background knowledge of mathematics. Therefore, the public outcry on the persistent low achievement of students in the subject is justified. It appears low achievement of students in mathematics is more pervasive in some domain specific areas of the subject such as plane geometry. The persistent low achievement in plane geometry in particular can be blamed on several factors such as the non-usage of instructional resources, inadequate activities and exercises, and poor approaches of teaching this area of mathematics. The activity-based approach of teaching and learning which enhances conceptual understanding and improves students' achievement in mathematics (Ilyas & Saeed, 2018) has long suffered disuse. Many teachers seem not to be aware of this approach of teaching as they are stuck to the traditional (lecture) method in teaching a practical subject like mathematics (Noreen & Rana, 2019). This has resulted in the increasing poor achievement levels in the subject and its related fields of study (Salifu, 2020). It is therefore, imperative to carry out an experimental study on the effectiveness of activity-based teaching method on students' achievement in plane geometry.

Background of the Study

Provision of quality education is the single most important responsibility of any government to its citizens. As put forward by Owusu-Ankomah (2007), Ghana can only become the roaring Africa and be equal with her Asian counterparts if education evolves to be the responsibility of all in the development of our dear country. He then encouraged citizens of Ghana to have an unflinching thirst for education which remains the bedrock for development. In this direction educational systems of countries are advocating not just education but quality and targeted education as a necessary determinant to national development. There is a gradual deliberate shift to mathematics education and its related programmes than do to the liberal form of education as seen decades ago. It is for this reason that education systems of countries that are anxious about their development put a great deal of emphasis on the study of mathematics and its related fields of study such as Science and Technology (CRDD, 2010).

The development of any nation will come to a halt if mathematics education is not purposefully targeted. Mathematics is an important vein in the development of nations. As stated by Serebour (2013), the effective knowledge of mathematics and its related programmes is the most influential determinant to the development in all aspects of human life. The relevance of mathematics in society has justified its inclusion in the compulsory subjects to be offered from the very beginning of formal education to the secondary level (Celik, 2018; Mereku, 1999). Mathematics has always been an important subject in the list of foundation subjects, and in most countries around the world, the subject forms an integral component of their curricular (Mereku, 1999). Mathematics occupies an enviable position in the school curriculum because the ability to understand and apply its concepts improves one's chances of climbing higher the academic ladder. It also influences the general well-being and functioning of individuals in the society (Hodanova & Nocar, 2016). According to Adajajsa (2001), mathematics is a field of study that cannot be avoided by any individual or nation and that the growing application of the knowledge of mathematics in other fields is a testimony to this assertion.

Mathematics became highly competitive since it was made to replace the ancient languages relating to Latin and Greek which before the early half of the 1900s were used to decide entry into higher education and many professions (Joseph, Adu, Ruth & Yaw, 2015; Mereku, 1999). Mathematics, in contemporary times, still serves this purpose as a basic entry requirement into certain programmes and professions around the world. In Ghana today, core mathematics has proven to be a difficult subject to pass into the tertiary level of the educational ladder. A credit pass of at least C6 (45% - 49%) or better in core mathematics in West African Secondary School Certificate Examination (WASSCE) is the basic requirement to pursue any programme at the tertiary level. This position attained by mathematics to be used as a yardstick to decide entry into higher learning in Ghana is not different in other countries. In Nigeria for instance, the same credit pass or better in general mathematics is the basic requirement for entry into all programmes (Abdulkarim & Baba, 2019).

The relevance of mathematics in society is abundantly visible from its unlimited applications in science and technology, and the general role it plays in our daily lives. No subject can stitch together the various branches of science than mathematics and without the prerequisite knowledge of it; knowledge of science will remain shallow, Moyer (as cited in Joseph, Adu, Ruth & Yaw, 2015). This signifies that without a proper grasp of the underlying principles in mathematics, the necessary skills and concepts needed in the development of science and technology cannot be acquired by students, a consequence that is not good for any nation. As put forward by Adenegan (2014), mathematics models reasoning, helps in developing scientific configuration and it is a key to solving problems and of drawing conclusions. Running of the world depends deeply on knowledge of mathematics as it determines the quality of life one lives, and it is necessary for the personal and professional development of individuals (Hodanova & Nocar, 2016). This simply implies that everyone needs mathematics in one way or the other to function properly in this ever-changing world of ours. It is not surprising therefore that, countries that are anxious about their development emphasise strongly the study of mathematics (CRDD, 2010).

Mathematics at the Senior High School (SHS) level has been categorised into two, elective mathematics and core mathematics. Elective mathematics is normally offered by those who have the intention of furthering their education on mathematics and its related programmes such as Science and Technology at the tertiary level. It is therefore, not compulsory for students of some programmes at the Senior High School (SHS) level. Core mathematics on the other hand is mandatory for all students who qualified from the Junior High School (JHS) level into Senior High School (SHS). Core mathematics is made compulsory at this level because it is a basic requirement to qualify one into the tertiary level of the educational ladder. It is also the reasoning of the core mathematics curriculum developers to allow every individual the opportunity to do some sort of mathematics since the knowledge of it is a necessary tool in the proper functioning of individuals in all spheres of life.

The 2010 core mathematics syllabus of Ghana has therefore, outlined seven content areas on which it reposes. One of the seven content areas of the syllabus is plane geometry (CRDD, 2010). Plane geometry encompasses polygons, Pythagoras theorem and its application (plane geometry I) and including circle theorem (plane geometry II). The knowledge and competencies developed at the level of Junior High School form the foundation on which mathematics at the Senior High School is built (CRDD, 2010). The mathematics curriculum is therefore, spiral in nature. Geometry happens to be one of the important content areas to have found its way into the mathematics curriculum from basic education to the secondary level and even beyond (NaCCA, 2019; CRDD).

The inclusion of plane geometry into the Senior High School core mathematics syllabus can be said to be the single most important thing to have been decided on by the planners of the mathematics curriculum. This is so because, geometry can be argued to be one of the most significant branches of mathematics to have ever been discovered. Geometrical knowledge plays a boundless role in man’s life and has no limit in its application both in the present and the future (Al-Khateeb, 2016). Geometry serves as the foundation on which mathematics rests on (Tatlah, Amin & Anwar, 2017). Again, geometry is considered an important component of the mathematics curricular of countries because geometrical knowledge is needed in critically analysing issues, interpreting the world around us, and helping us to study other areas of mathematics and its related fields of study (Ozerem, 2012; Fabiyi, 2017). No wonder geometry occupies a privileged position in the mathematics curricular of the developed world (Report of the Royal Society/Joint Mathematical Council Working Group, 2001). The role of geometry in mathematics and society at large has gone further to support why a great number of developments in recent times in the study of mathematics are primarily geometrical in nature (Jones, 2000).

Despite the importance of geometry to man and the society at large, this branch of mathematics can be said to be one area that has not received the best of teaching and learning. Geometry has been proclaimed by many to be the most difficult part to teach and learn in mathematics (Tay & Mensah-Wonkyi, 2018; Serin, 2018; Sah, 2016; Adolphus, 2011). This explains why students dodge any questions relating to geometry when they have the least opportunity to do so (Tay & Mensah-Wonkyi, 2018). The perceived causes of difficulties relating to the teaching and learning of geometry include but not limited to poor approaches of teaching and inadequate teaching and learning resources (Fabiyi, 2017). The teacher has been heavily accused for using instructor-centred approaches such as the traditional (lecture) method to the detriment of learner-centred methods such as the activity-based teaching approach in teaching this important area of mathematics (Adolphus, 2011; Fabiyi, 2017; Tay & Mensah-Wonkyi; 2018; Salifu, 2020).

The traditional method of teaching and learning mathematics and for that matter geometry is characterised by giving rules, properties and procedures for learners to memorise and following this with exercises (Nabie, 2000). In this approach of teaching, the teacher is perceived to be the reservouir of all knowledge who comes to state the rules, properties, and procedures to answering geometry questions whiles the students' task in the classroom is to bring along pen and notebook to copy notes (Shah, 2019; Tay & Mensah-Wonkyi, 2018; Pokhrel, 2018; Festus, 2013). Several researchers are of the view that the over reliance on the traditional approach of teaching has resulted in students' low achievement in plane geometry in particular and mathematics as a whole (Adolphus, 2011; Fabiyi, 2017; Tay & Mensah-Wonkyi; 2018; Salifu, 2020). This has necessitated researchers and educationists to look at other methods to better teach this area in particular and mathematics in general to students.

Therefore, the National Council for Curriculum and Assessment (NaCCA) (2019) has specified hands and minds-on activities (activity-based approach) to teaching geometry in particular and mathematics in general at all levels. In this approach of teaching, students get the opportunity to identify, measure, and compare angles and discuss their results thereby increasing their understanding of the concepts to be learnt. In this way according to NaCCA (2019), the study of mathematics will be fun to learners and it will provide them the opportunity to visualise the cultural value in the subject. This will in effect improve the low achievement levels of students in mathematics in general and geometry in particular, (NaCCA, 2019). To support this argument, the Report of the Royal Society/Joint Mathematics Council Working Group (2001) has stretched the need to teach geometry through carefully structured activities and proper use of teaching-learning resources.

But a careful look at the teaching and learning culture in Ghanaian classrooms, the mathematics teacher has gone contrary to this proposal. The traditional method of teaching and learning has therefore gained favour in the sight of the teacher and dominated our classrooms (Shah, 2019; Tay & Mensah-Wonkyi, 2018; Pokhrel, 2018; Festus, 2013). According to Nabie (2000), teachers' unwillingness to depart ways with this practice (traditional method) of teaching mathematics only stems from internal and external pressures to complete the syllabus, inadequate space and resources, unnecessary value placed on examinations, and the perceived difficulties involved in carefully planning hands and minds-on activities.

Nabie (2000) therefore, placed a passionate appeal to mathematics instructors to as a matter of urgency introduce innovative teaching approaches such as the activity-based teaching method which can improve problem solving skills of students, mathematics understanding and interest into their teaching profession in this era of mass failure in mathematics. Though there is no one particular endorsed method of teaching mathematics and for that matter geometry, teaching by giving rules, properties and procedures for students to memorise and following this with exercises is not encouraged (Nabie, 2000). The activity-based teaching approach has therefore, gained favour in recent times through the old Chinese proverb that: To hear is to forget, to see is to remember and to do is to understand (Affum, 2001). Affum (2001) is of the view that the activity-based teaching approach creates understanding of concepts and improves achievement levels of students in the learning of mathematics in general and geometry in particular.

Statement of the Problem

The persistent low achievement of students in mathematics has gained attention in the larger society. Literature is replete with the fact that students are performing poorly in in the subject (Varaidzaimakondo & Makondo, 2020;

Abreh, Owusu, & Amedahe, 2018; Asomah, Wilmot & Ntow, 2018). It appears low achievement in mathematics is more pervasive in some domain specific areas of the subject such as plane geometry. In a study conducted by Tatlah, Amin and Anwar (2017), they concluded that, learners in general have problems relating to drawing and interpretation of geometrical shapes and figures and they are unable to perform calculations on problems involving geometry. As proclaimed by the Report of the Royal Society/Joint Mathematical Council Working Group (2001), geometry is one area of mathematics that seems easy to teach and learn but in reality it is not. This paradoxical nature of geometry has created several problems for the effective teaching and learning in this field of mathematics. It is strongly argued that improper application of rules, procedures and strategies by learners emanating from poor approaches of teaching leads to superficial understanding of the concepts of geometry which is a possible source of misconceptions (Woodward, Baxter & Howard, 1994). Learners therefore, have been accused by Sah (2016) for always trying to memorise the rules and properties of geometry without the slightest idea that geometry cannot be learnt by rote. To Sah (2016), learners are weak in this field of study and are always complaining that geometry is boring and difficult to learn without putting in their best. This explains why students dodge questions relating to geometry when they have the least opportunity to do so, and a more reason why those who finally answer questions on geometry do not perform well (Tay & Mensah-Wonkyi, 2018). The appalling nature of students' performance in plane geometry in particular is not limited to any geographical area. In Ghana for instance, students' poor performance in plane geometry is evidently visible from the chief examiner's reports on the West African Secondary School Certificate Examination (WASSCE) over the years.

The chief examiner's report on the West African Secondary School Certificate Examination (WASSCE) has consistently stretched general students' low achievement in plane geometry in particular. For instance, in the year 2021, there were three questions on plane geometry II in Paper 2 but students could not apply the necessary theorems and principles to solving them. The general comments from the chief examiner's report on plane geometry categorically stated that candidates in general could not solve questions relating to this domain of mathematics. The report then suggested that candidates should read questions carefully before attempting them and also that teachers should give more exercises and encourage students to work on their own. The report further stated that teachers should have time for low achievers and help them to identify and apply the basic principles and skills needed in this topic. One of the questions of the 2021 West African Secondary School Certificate Examination (WASSCE) is represented in Figure 1. In Question 3 (a), students were to solve for the value of m. Question 3(a) is represented in Figure 1 as indicated.

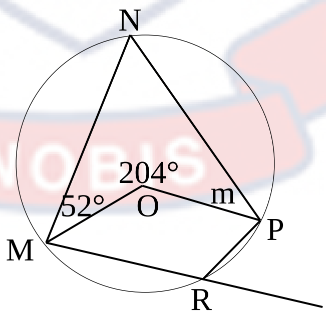


Figure 1: WASSCE 2021 Question 3(a)

From Figure 1, the question reads: MNPR are points on a circle with centre O. Angle NMO is 52° and the reflex angle at O = 204°. Find the value of m. From the chief examiner's report, many candidates could not answer correctly this question. Students could not apply the principle that < MRP is $\frac{1}{2}$ of 204° = 102°. They did not also realise that opposite angles of the cyclic quadrilateral MNPR are supplementary and for that matter < MNP = (180° - 102°) = 78°. Students could not therefore, find the sum of interior angles of quadrilateral MNPO as equal to 360°. They therefore, could not find the appropriate value of m such that m = 360° − (52° + 204° + 78°) = 26°.

Also, in the year 2020, there were again three questions on plane geometry II in Paper 2 but students under performed in all of them. The general comments from the chief examiner's report on plane geometry categorically stated that candidates in general could not solve questions relating to plane geometry and especially problems concerning cyclic quadrilateral. The report then suggested that the topic circle theorem (plane geometry II) should be explained well in schools and also that teachers should encourage candidates to work in groups when it comes to teaching and learning pertaining to this domain of mathematics. One of the questions of the 2020 West African Secondary School Certificate Examination (WASSCE) is represented in Figure 2. In Question 3 (a), students were to solve for the value of y. Question 3(a) is represented in Figure 2 as indicated.

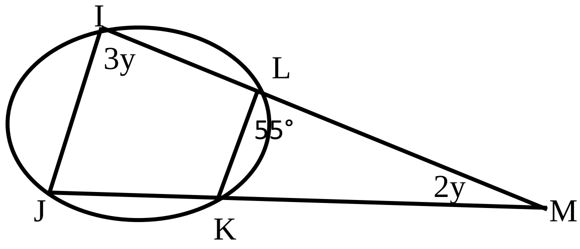


Figure 2: WASSCE 2020 Question 3(a)

From Figure 1, IJKL are points on a circle such that angle JIL = 3y and angle KML = 2y. If angle KLM = 55°, find the value of y. From the chief examiner's report on this question, many candidates presented answers that showed that they were merely guessing. Students could not apply the principle that opposite angles of a cyclic quadrilateral are supplementary. They did not also realise that angles on a straight line add up to 180°. They therefore, could not find the value of y as required.

Again, in the year 2019, the chief examiner's report has it that though some students were able to solve Question 12 (a) on plane geometry, others used their own variables and in the process got lost on the way. Question 12 (a) is represented in Figure 3 as indicated.

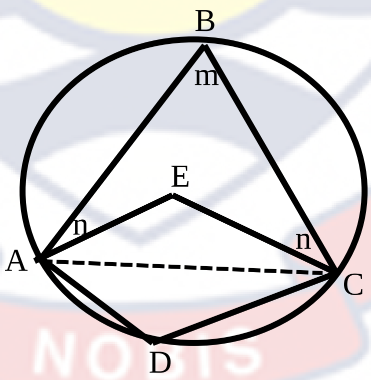


Figure 3: WASSCE 2019 Question 12 (a)

From Figure 3, quadrilateral EADC is a rhombus and E is the centre of the circle ABCD. Students were supposed to find the values of m and n. This posed a challenge for some students who decided to use their own variables and could not therefore, reached the desired conclusion. They therefore, could not find the values of m and n as required.

In 2018 students were presented with a question in plane geometry of which they could not solve. The question is presented in figure 4. According to the chief examiner's report for 2018, many candidates could not apply the principles of cyclic quadrilateral when they were asked to find the value of < PRQ from Figure 4. They therefore, ended up adding 65° to 48° and subtracted the result from 180° which gave them wrong answers. It was then suggested by the chief examiner to give adequate amount of exercises to students to practice.

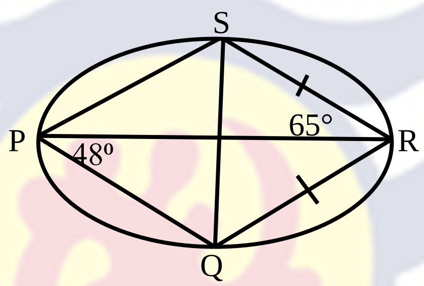


Figure 4: WASSCE 2018 Question 4 (b)

Figure 4, illustrates the question: if PQRS are points on a circle and |QR| = |RS|, find the value of < PRQ. Students did not realise that < QSR = < QPR = 48° (angles formed by the same chord in the same segment). They did not also recognise that triangle QSR is isosceles and that < RSQ = < RQS = 48°. Therefore, majority of the students could not find the value of < PRQ as equal to $180° - (48° + 48° + 65°) = 19°$.

Students' inability to solve plane geometry questions was again contained in the 2017 chief examiner's report. The chief examiner's report categorically stated that students are weak when it comes to solving problems relating to plane geometry and especially in the areas of cyclic quadrilateral, chord theorem and tangent. In 2017 WASSCE, both problems a) and b) of Question 8 were on plane geometry. In Question 8 (a) for instance, students were required to solve for the value of y as contained in Figure 5.

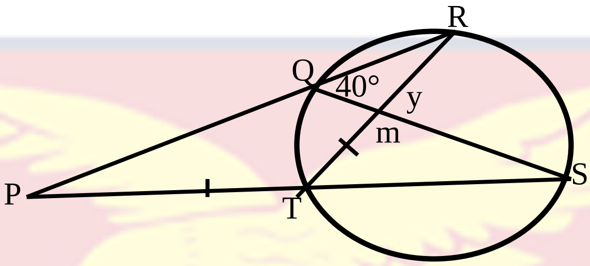


Figure 5: WASSCE 2017 Question 8(a)

The question was: if angle RQS = 40º, |RT| = |PT| and angle RMS = y. Find the value of y. Most students encountered some difficulties in solving for the value of y. The chief examiner's report on this question stated that students have inadequate understanding on basic geometrical concepts and principles and more especially on properties of cyclic quadrilateral and their applications. Question 8 (b) was also another problem area for students. Question 8 (b) was given as: XY is a tangent to a circle LMN at the point M. XLN is a straight line, <NXM = 34º and <NMY = 65º. Find the value of <MLX and <LNM. The chief examiner's report on Question 8 (b) indicated that students could not draw the required diagram, could not apply the sum of two interior opposite angles and exterior angle principle of a triangle and have inadequate knowledge also on base angles principle of an isosceles triangle. It was then suggested that students should spend more time in learning the theories and principles of plane geometry.

Thus, their reports point out that plane geometry is a problematic area to most students. There is therefore, the need to take necessary steps to addressing the cancer of poor performance in plane geometry. It is in the light of this that, the National Council for Curriculum and Assessment (NaCCA) (2019), stretched the need to teach mathematics in general and plane geometry in particular through hands and minds-on activities (activity-based approach). In this way according to NaCCA (2019), the study of mathematics will be fun to learners and it will provide them the opportunity to visualise the cultural value in the subject. This will in effect improve the low achievement levels of students in mathematics in general and geometry in particular, (NaCCA, 2019).

To Festus (2013), the concepts and properties of plane geometry II (circle theorem) can actually be taught well through the activity-based teaching approach in the absence of the GeoGebra software where worksheets can be created for students in groups to measure the various angles and discuss to discover for themselves all the properties. In a study conducted by Albadi (2019) to find out the impact of the activity-based approach of teaching on students' achievement, it came out that students in general have positive perceptions towards this approach. Again, the activity-based approach of teaching and learning in the view of students encourages the creation of active learning environment, leads to conceptual understanding of concepts, creates interest towards learning and it is an interesting and useful method for learning in general (Parekh, Munjappa, Shined & Vaidya, 2018). To Pokhrel (2018), activity-based teaching approach should be every instructor's target since it develops in learners' deep understanding of mathematical concepts and skills as well as positive attitudes and values towards the study of the subject. To ascertain the efficiency of the activity-based approach of teaching plane geometry in particular and mathematics in general, it is imperative to carry out an experimental study on the effectiveness of activity-based teaching method on students' achievement in plane geometry.

Purpose of the Study

The purpose of the study was to investigate the effectiveness of the activity-based teaching approach on students' achievement in plane geometry.

Research Questions

Three research questions guided the study. These are:

1 To what extent do the activity-based approach and the traditional method of teaching and learning plane geometry affect students' achievement?

2 How can the improvements in teaching using the activity-based teaching approach and enhanced conceptual understanding of concepts on plane geometry be explained and understood?

3 What perceptions do students hold about the activity-based teaching approach in learning plane geometry?

Research Hypotheses

To determine the effect of using the activity-based approach as an instructional tool in teaching and learning on the achievement of students in plane geometry, two research hypotheses were formulated to guide the study:

H_0 1: There is no statistically significant difference between the post-achievement test mean scores of females and their male counterparts of students taught lessons with Activity-Based Approach (ABA) of teaching and learning plane geometry.

H_0 2: There is no statistically significant difference between the post-achievement test mean scores of students taught lessons with Activity-Based

Approach (ABA) and their counterparts taught through the traditional method of teaching and learning plane geometry.

Significance of the Study

The study was purported to use the activity-based teaching approach in teaching plane geometry which appears to be a complex area of mathematics to teach and learning to students of Senior High School. It would be beneficial to government, district education offices, teachers, departments of mathematics in the various universities, students and other researchers. Government might be eager to get data on the state of affairs in Senior High Schools in terms of students' achievement in especially mathematics. This would inform government as to whether the heavy budgetary allocation towards the study of mathematics is yielding the desired results. Teachers may be given in-service training by the government to improve upon their methods of teaching especially practical subjects like mathematics. The government through the Ghana Education Service (GES) may then make the teaching and learning of mathematics in schools to be carried out through the activity-based approach of teaching as proposed by National Council for Curriculum and Assessment (NACCA).

Again, the district education offices within the study areas will get to know how teacher related factors such as their teaching approaches are contributing to students' low achievement in mathematics in general and plane geometry in particular. This will help the education office to take the necessary steps to addressing this challenge of low achievement in mathematics. There may be the need to organise in-service training for teachers on the importance of using innovative methods such as the activity-based approach of teaching mathematics. The necessary resources may also be provided by the district education offices to help mathematics teachers teach through activity-based approach with confidence and ease. Monitoring and evaluation of teachers' instructional approaches by the district education offices may be intensified in order to harvest the benefits of innovative methods in teaching mathematics.

Also, departments of mathematics in the various universities may see the need to restructure their programmes to include innovative methods such as the activity-based teaching approach and the use of Information, Communication and Technology (ICT) in teaching special topics like geometry in mathematics. The departments may specifically target difficult topics of the mathematics syllabus that they envisage may not be taught or handled well by teachers and to include these with the necessary instructional resources in their programmes. This is so because; having a deeper content knowledge and understanding of mathematics concepts is good but may not be sufficient in teaching the subject which is seen by many to be an abstract quantity. Researchers who will have the intention to replicating this study will have the baseline information to start with. The student will be the ultimate beneficiary of this research work if it is carried out successfully. They will by the activity-based teaching approach develop sustained interest in studying mathematics and its related fields of study. This will consequently improve learners' mathematics achievement which is the aim of every student in studying mathematics.

Delimitations of the Study

There are 30 Senior High Schools in the Upper West region of Ghana. Out of this number, three are Category A schools and the rest of the 27 are either Category B or C. This study therefore, involved only the Category A schools in the region. Category A schools were considered in this research work because they are relatively well resourced than the other category of schools. Therefore, this category of schools was purposefully sampled to take part in the study. The reason is that, with the available resources, it would enable the researcher to get in-depth knowledge on students' performance in plane geometry as they learn through the activity-based approach of teaching and learning. Only two intact classes one each from the two schools randomly sampled were involved in the study. The students were pre- and post-tested on questions involving plane geometry (I and II) after teaching them through the two approaches (activity-based approach and the traditional method). The experimental group (school A) were taught through the activity-based approach and the control group (school B) through the traditional method. Only students of the experimental group answered a questionnaire on perception towards the activity-based approach of teaching and learning and its effect on teaching plane geometry. Focus group discussion and an observational guide were also included in the instruments used in gathering data on the experimental group. School administrators and teachers were excluded from the study.

Limitations of the Study

Collecting the two forms of data (quantitative and qualitative) simultaneously was labour intensive for a single researcher and embedding the qualitative data can be said influenced the data on students' perceptions. The pre-achievement tests was conducted first, followed the observational guide, the post-achievement tests, the questionnaires, and finally the focus group discussion. Therefore, if a student was not able to answer the questions, he/she may conclude that the activity-based teaching approach (ABA) is not appropriate for teaching and learning and vice versa. The findings of the study are limited also to the selected category A schools and schools of similar characteristics. Again, the research findings are limited to plane geometry. This limitation further restricts the generalisation of the results of the study to other content areas of mathematics. The duration of the treatment was considered a limitation. The three weeks considered for the experimental (treatment) group was short in obtaining absolute results on students' achievements and experiences.

Definition of Terms

In this study, instructor and teacher are used interchangeably and also teaching methods and teaching approaches are interchangeably used. Again, the activity-based approach (ABA) as used in this study relates to identification, measurement and comparing plane geometric angles by students.

Organisation of the Study

The entire study was organised into five chapters. Chapter one consisted of an introduction to the study; background to the study, statement of the problem, and purpose of the study. It included also research questions, significance of the study, delimitations and limitations, definition of terms and finally, organisation of the rest of the study. Chapter Two considered the review of related literature pertaining to the study and was guided by the research questions and hypothesis, and the conceptual framework. Chapter Three dealt with the research methods used in the study. It covered research design, study area, population, sampling procedure, data collection instruments, data collection procedures, data processing and analysis, and chapter summary. Chapter Four covered the two interrelated areas of results and discussions of the data so gathered. Chapter Five gave a summary and conclusions of the study, recommendations and suggestions for further research studies.

CHAPTER TWO

LITERATURE REVIEW

Overview

The purpose of the study was to investigate the effectiveness of the activity-based teaching approach on students' achievement in plane geometry. This section reviewed literature adjudged to be relevant to the study based on the research questions and hypothesis. It was organised under ten headings: concept of plane geometry, learning difficulties in plane geometry, misconceptions in learning mathematics, teaching and learning resources, and gender and mathematics achievement issues. It further looked at methods of teaching plane geometry, activity-based teaching approach, students' perception towards the activity-based teaching approach as well as the theoretical and conceptual frameworks.

Concept of Geometry

Geometry as a field of study has a long standing history that can be traced. One can only say that geometry and mathematics itself are age mates. In the olden times when the flood of Neel River washed away the symbol of measurement of agricultural areas, it became prudent then to measure and to re-measure the agricultural area among farmers (Noreen & Rana, 2019). The knowledge of geometry was then in display. It is argued strongly that geometry forms the foundation on which mathematics stands on and without geometry, knowledge of mathematics will remain hollow (Tatlah, Amin & Anwar, 2017). Geometry was coined from two Greek words which mean earth (geo) and measure (metry) as stated by Rana and Noreen (2019). Geometry then means measurement of the earth. Geometry measures lines, points, curves and surfaces as put forward by (Tatlah, Amin & Anwar, 2017). To these researchers, geometry can only be in the form of line geometrics (plane geometry I) and or radius geometrics (plane geometry II). Serin (2018) on the other hand considers geometry to be measurement of space and shape.

The 2010 core mathematics curriculum is built on seven content areas of which plane geometry is at the heart of it. Geometry happens to be one of the content areas that are found in all levels of the academic ladder. The contents of geometry are also spiral in nature. At the Senior High School level, the content areas of geometry covered by the mathematics curriculum are polygons, Pythagoras theorem and its application (plane geometry 1) and circle theorem (plane geometry II) including tangents. Construction has also been treated under plane geometry in other jurisdictions. The inclusion of plane geometry into the Senior High School core mathematics syllabus can be said to be the single most important thing to have been decided on by the planners of the mathematics curriculum. This is so because, geometry has been argued to be one of the most significant branches of mathematics to have ever been discovered since geometrical knowledge plays a boundless role in man's life and has no limit in its application in the future (Al-Khateeb, 2016). Geometry serves as the foundation on which mathematics rests on (Tatlah, Amin & Anwar, 2017). Again, geometry is considered an important component of the mathematics curricular of countries because geometrical knowledge is needed in critically analysing issues, interpreting the world around us, and helping us to study other areas of mathematics and its related fields of study (Ozerem, 2012; Fabiyi, 2017). No wonder geometry occupies a privileged position in the mathematics curricular of the developed world

(Report of the Royal Society/Joint Mathematical Council Working Group, 2001). Noreen and Rana (2019) postulated that geometry affects every individual from birth to grave and has a representation in the cultural development of persons and societies. Again, geometry is seen to be playing an integral part in our cultural dispensation and our aesthetic, intuitive and visual senses can only be appealed to by geometry (Jones, 2002). The relevance of geometry in society has gone further to support why a great number of developments in recent times in the study of mathematics are primarily geometrical in nature, Jones. To this end, Noreen and Rana (2019) have a firm conviction that the field of geometry is blessed by nature and the scientific world in that the environment in which man lives is replete with geometrical shapes and resources. Therefore, the teaching and learning of geometry in the abundance of these resources should be done with minimal difficulties.

Learning Difficulties in Plane Geometry

Geometry as a field of study may be considered the most widely used domains of knowledge, it is the gateway to mathematical thinking and forms part of our everyday life and the environment in which man lives in is engrossed with geometrical shapes and figures (Noreen & Rana, 2019). It is believed that learners start to comprehend and appreciate the world around them by means of geometry (Serin, 2018). Despite the fact that geometry forms part of life and geometrical shapes and figures are easily accessible to both instructors and learners, this area of mathematics presents many challenges for the teacher to make the necessary connection to teaching and learning. It has been argued strongly that geometry is a very difficult and complex area of mathematics to teach and learn (Serin, 2018; Al-Khateeb, 2016; Adolphus, 2011). Learners seem to have general problems relating to drawing and interpretation of geometrical shapes and figures and they are unable to perform calculations on problems relating to geometry (Tatlah, Amin & Anwar, 2017). Geometry has therefore, become a major problem area for students and they dodge problems relating to this area of study when options are provided (Tay & Mensah-Wonkyi, 2018). As proclaimed by the Report of the Royal Society/Joint Mathematical Council Working Group (2001), geometry is one area of mathematics that seems easy to teach and learn but in reality it is not.

The problems relating to teaching and learning of geometry are multifaceted. These problems emanate from several sources including government and school authorities, students and teachers. Several researchers are pointing accusing fingers at government and school authorities on the issues of infrastructure and teaching and learning resources as well as not training teachers on how to use technology in teaching this important area of mathematics known as geometry. In a study conducted by Onaifoh and Ekwueme (2017), it became evident that schools did not have enough computers, geometry software and teachers were not trained on basic computer and mathematical software skills. To them, in-service training on how to use geometry software to teaching and solving geometrical problems was non-existent. Again, inadequate technological resources in particular and general non-existents of teaching and learning resources in schools are contributory factors to the difficulties perceived in teaching and learning geometry (Panthi & Belbase, 2017). It was again identified that inadequate teaching and learning resources and the voluminous nature of the mathematics curriculum leads to teaching and learning problems in geometry. Insufficient time allocation to mathematics and its various branches of study has also been considered a major hurdle to teaching and learning geometry (Fabiyi, 2017).

Learners are not also left of the hook on issues regarding learning of geometry. Learners have been generally accused for having very weak background knowledge on the study of geometrical concepts and principles (Fabiyi, 2017; Sah, 2016; Adolphus, 2011). Learners have also been accused by Sah (2016) for always trying to memorise the rules and properties of geometry without the slightest idea that geometry cannot be learnt by rote. To Sah (2016), learners are weak in this field of study and are always complaining that geometry is boring and difficult to learn without putting in their best. It has also come to light that learners have general problems in calculations involving geometry and drawing of geometrical shapes and figures (Tatlah, Amin & Anwar, 2017).

Teachers have also been accused of helping to create the many difficulties pertaining to teaching and learning of geometry. Teachers just like learners are accused of having poor background knowledge in the domain of geometry (Adolphus, 2011). This may explain why teachers cannot properly teach the topic geometry. To this end, Adolphus (2011) is of the view that teachers' inability to properly teach the concept and properties of geometry leads to the many learning problems learners have to struggle with in geometry. There has also been an argument that many unqualified teachers in the system are called upon to teach mathematics in general and geometry in particular a reason both teachers and learners have problems relating to the teaching and learning in this domain of mathematics (Festus, 2013). The biggest worry of this situation is that these teachers over rely and misuse the traditional teaching approach (lecture method) in the teaching of mathematics compelling learners to memorise theorems and properties without understanding leading to massive failure in the subject (Salifu, 2020). In this direction, Fabiyi (2017) has a firm believe that the traditional teaching approach coupled with several misconceptions in mathematics and geometry in particular serve as obstacles to proper teaching and learning of the subject.

Misconceptions in Learning Mathematics

Mathematics is one domain of human learning that is engrossed with misconceptions (Ay, 2017; Mary, Miheso & Ndethiu, 2016; Ojose, 2015). Misconceptions are wrong notions that are developed about a concept which can hinder the smooth teaching and learning of mathematics (Waluyo, Muchyidin & Kusmanto, 2019). Ojose, sees misconceptions to be erroneous understandings and misinterpretations conceived by learners based on ill-information. To Ilyas and Saeed (2018), misconceptions can best be described as impediments to the effective teaching and learning process. In the same vein misconceptions can be seen as inappropriate beliefs that are based on defective understanding about concepts (Ajayi, 2017). Misconceptions can therefore, be described here as both formal and informal believes that are held about a concept which are inconsistent with what is generally accepted. What is worthy of mentioning from literature is that, it is not only those learners believed to be weak that have misconceptions in the study of mathematics (Ilyas & Saeed, 2018).

Learners of all categories come to class or school with errors and misconceptions that they have developed during previous classes or from the community (Mohyuddin & Khalil, 2016). This often creates difficulties in the on-going learning of geometrical concepts and as a consequence producing poor achievement outcomes in this field. Though misconceptions can be positive or negative, there is certainly a need to identify and rectify these in order to help learners progress in the development of mathematical knowledge. It is unavoidable that learners enter higher education with misconceptions about how the world operates. Often these preconceptions align with concepts and theories to be learnt in a course and do not pose a hindrance to further understanding. While misconceptions can be significant barriers, they can also present opportunities to enhancing the teaching and learning of new material (Verkade et al, 2017). When learners are confronted with a gap between what they think is right and what is correct, the gap may generate into confusion. It is important therefore, that instructors work with their students to identify commonly held misconceptions to help achieve the best learning outcomes. To ensure learners achieve a strong understanding of the core concepts of mathematics, it is necessary to identify, assess and replace previously held misconceptions with the information adjudged to be consistent with the accepted concepts of the subject. Verkade et al (2017) are of the firm believed that, it is often stress-free for learners to discard or associate with new information that is easier to comprehend and more intuitive understandings of the world.

In the face of this challenge, instructors need to listen to learners and work with them with the reason of breaking down that barrier of misconceptions to allow for conceptual understanding. Verkade et al believe that conceptual understanding can only take place under at least two situations. In one situation, learners may have accurate but incomplete prior knowledge of a concept. In this case, the learning process should be geared towards filling the gaps in students' understanding of the concepts with accurate knowledge. In the second situation, a learner comes to class with prior knowledge that is in conflict with what is to be learnt. This situation calls for evaluating, revising and replacing the improper prior knowledge with thoughts that are in consonant with the new concept to be learnt. The first step to correcting mathematical misconceptions is to understand and recognise that the misconception really exists. This may be easy for the person with the informed knowledge, but it is of necessity that the learner holding the misconception is made aware to the fact that what he/she holds is a misconception. This process of evaluation may be achieved if instructors design their teaching to purposefully assess learners' prior knowledge and tickle them to answer questions that may contain a misconception in order for learners to come to terms with the reality. The second condition becomes relevant if the learner is aware of the misconception he/she holds. This is the stage to motivate learners to search for the appropriate knowledge to replace the previously held misconception.

Both general and specific misconceptions exist in the teaching and learning of mathematics. According to Ojose (2015), the immediate source of misconception is the nature of mathematics itself. Ojose argued then that the right step to appropriately plan instruction that will be of benefit to learners is for instructors to know the nature and source of misconceptions. Allen (2007) identified four general misconceptions that are held in mathematics. To Allen, many believed that mathematics is characterised by rules, procedures and properties that cannot be understood. The perception out there is also that it is normal to fail mathematics because mathematics as a subject was created for a certain group of persons and more especially the intelligent in society. One other misconception held by people is that mathematics is not important to those who do not want to further their education in mathematics and its related programmes. Again, the role mathematics plays in our everyday life and society at large is always under estimated. According to Tetteh, Wilmot and Ashong (2018), females who perform well at mathematics or are mathematicians are often considered by some men as abnormal and may risk becoming wives. This constitutes a cultural misconception in that females, who are good at mathematics and its related of fields of study are not branded names in other jurisdictions but are praised and encouraged. Also, it is worthy of mentioning that some females believe a good mathematician will most likely be a teacher (Uwineza, Rubagiza, Hakizimana & Uwamahoro, 2018). This is a misconception of the value of mathematics in society and the many professions that necessarily need the knowledge of mathematics to function. Having the thoughts that the place of mathematics is the teaching field is a misconception that needs appropriate steps to identify and remediate.

In specific domains of mathematics such as algebra and geometry some misconceptions can also be identified. There are learners who believe strongly that $\frac{1}{9}$ is greater than $\frac{1}{3}$ beacuse 9 is greater than 3 (Ojose, 2015). Also, learners answering 3x + 4 as 7x, is another misconception (Mary, Miheso & Ndethiu, 2016). In the domain of geometry, learners are believed to have inadequate knowledge and misconceptions in relation to its study (Ozerem, 2012). Kriswanto (2013) identified three types of misconceptions that are related to the study of tangents in geometry: misconception relating to theory arises when learners are wrong in their explanation to a tangent, correlational misconception occurs when learners are unable to relate one concept of a circle to the order and misconception relating to classification occurs when learners get their definition of the parts of the circle wrong. Kriswanto is of the view that tangent to a circle is one area that is still preoccupied with misconceptions. Mooney, Briggs, Hansen, McCullouch and Fletcher (2018) share the view that shape orientation and incorrect naming of X- and Y-axes are common misconceptions in geometry. Many misconceptions learners encounter in the field of geometry can actually be avoided if proper planning and teaching occur according to Mooney et al (2018). The trick to avoiding these misconceptions will be to constantly change the orientation of shapes in the teaching and learning process. Geometry as a field of study if not handled properly in the teaching and learning situation will hatch several misconceptions. Fabiyi (2017) then gave a suggestion that topics of geometry should be organised in such a manner that will allow for easy teaching and learning in order to avoid misconceptions. To Waluyo, Muchyidin and Kusmanto (2019), any teaching and learning process that is not grounded on prior knowledge of learners can only lead to misconceptions.

Waluyo, Muchyidin and Kusmanto (2019) appear to suggest that teachers are not aware of learners' misconceptions; the assessment procedures are not helpful enough in identifying misconceptions and that, instructors in general are not vigilant about the answers learners provide which present a major cause of worry. Misconceptions when not corrected in time will inhibit the smooth teaching and learning of geometry in the immediate future (Ojose, 2015). It is strongly argued that improper application of rules, procedures and strategies by learners leads to superficial understanding of the concepts of geometry which is a possible source of misconceptions (Woodward, Baxter & Howard, 1994). Learners have inadequate knowledge and misconceptions in relation to geometry (Ozerem, 2012). To remediate this, learners are advised to always explain their answers.

In a study conducted by Ilyas and Saeed (2018), several sources of misconceptions were identified: textbooks, instructors, learners and peers and parents. This is so because leaners have faith in these sources and as such will not question their authenticity. Therefore, any information emanating from the said sources will be taking 'hook, line and sinker'. To Ilyas and Saeed (2018), most of the instructors are not aware of learners' misconceptions. Instructors therefore, teach without knowing whether learners have existing misconceptions in the teaching and learning process or not. These researchers then encouraged the use of the activity-based teaching approach to help eliminate the misconceptions of students. Other sources of misconceptions were as well identified by Ajayi (2017) to include life experiences of learners and the language of a particular culture. Learners come from different backgrounds and have unique experiences. These experiences are brought to bear in the teaching and learning process. It becomes incumbent upon the instructor to identify those experiences that are not inconformity with accepted rules and procedures and give remediation during the teaching and learning process. There are several ways of carrying out this assignment. The instructor should anticipate that learners will be coming to class with various forms of misconceptions in relation to the area to be studied and prepare in advance to handle them if any, encourage learners to discuss their answers with their colleagues, frequently visit known misconceptions and assess for the validity of students' responses as frequently as possible Ajayi, 2017). Identifying and treating misconceptions has remained a huge task to geometry teachers (Al-Khateeb, 2016). But the trick is to allow learners to construct their own knowledge which will help them to easily identify and remediate any misconceptions since the field of mathematics is engrossed with concepts which are easily misconstrued when not handled properly (Shah, 2019). This suggests that the approach or method and the teaching and learning resources adopted by instructors in the teaching of mathematics and geometry in particular play a major role in how learners identify and remediate misconceptions, and how generally they learn the concepts and properties as relating to this field of study.

Teaching and Learning Resources in Mathematics

Teaching and learning of mathematics in general has reached a stage whereby verbally communicating rules and properties will not do the trick. The use of mathematical resources for teaching and learning has long been stretched by curriculum developers and educationists. The core mathematics syllabus has stretched the need to constantly engage mathematics teaching and learning resources and more especially technology in the teaching and learning situation (CRDD, 2010). Again, the National Council for Curriculum and Assessment (NaCCA) (2019), has stretched the need to teach mathematics through the use of teaching and learning resources and for that matter the use of ICT tools. To put more emphasis on the usage of teaching and learning resources, it is a requirement for a column to be created in lesson plans of teachers where instructional resources to be used for any lesson are stated. Mathematics teaching and learning resources are naturally and artificially created materials and devices that are employed to aid teaching and learning of the subject (Agyei, 2013). Teaching and learning resources are also seen simply as pathways of teaching which are usually used by instructors to make real a concept in the teaching and learning situation (Samuel, 2009).

The field of geometry is blessed with both natural and artificial resources. The environment in which man lives may be by divine plan is replete with geometrical shapes and resources (Noreen & Rana, 2019). To them, buildings, walls, tiled floors of rooms and many other structures in the environment are geometrical in nature. Mathematical resources can be classified as everyday materials, worksheets, mathematical games, textbooks, ICT and manipulative (Agyei, 2013). In the same vein sketches, diagrams, images, written materials and films are also necessary forms of mathematical resources (Busljeta, 2013). To Adelodun and Asiru (2015), instructional resources can further be classified as audio, visual and audio-visual. Teaching and learning resources also include worksheets, projector and instructional charts (Ajoke, 2017). From literature, GeoGebra software, worksheets, sketches, mathematical games and textbooks are the mathematical resources frequently cited to be used in the teaching and learning of geometry.

Gathering mathematical resources for the teaching and learning process is a requirement but not sufficient enough to have a fruitful instruction. The selection of mathematical resources for the teaching and learning situation should be based on certain factors. Busljeta (2013) is of the view that choosing mathematical resources should be based on some considerations. These considerations must necessarily include the characteristics of the teaching and learning resource, experience and skill of the instructor in using the resource, the skill to be learnt should be contained in the teaching and learning material and finally, the interest and characteristics of learners must also be considered. According to Agyei (2013), the attractiveness, durability, size and easiness to manipulate the mathematical resource constitute the physical criteria of selecting teaching and learning resources. To him, the ability of the resource to be used for abstraction, to contain the mathematical concept to be taught, and the ability for it to be used for multiple purposes constitute the pedagogical criteria of selecting mathematical teaching and learning resources.

Selecting mathematical teaching and learning resources will be of no benefit if they are not used for the intended purpose. Reasons for using mathematical teaching and learning resources in lesson delivery are varied. The intention of making the lesson practical, realistic, interesting and creating the opportunity for both the instructor and learner to actively engage in the teaching and learning process leads some instructors to use teaching and learning resources (Ajoke, 2017). Again, improving students' understanding of mathematical concepts and achievement, motivating and attracting the attention of learners, for teachers to effectively communicate with students and elimination of boredom are other reasons for using teaching and learning resources (Adalikwu & Iorkpilg, 2013). The intention of reducing the length of time to be spent on teaching and learning, allowing for more time to practice, gaining attention and efficient retention of material presented by learners are some motivating factors for using teaching and learning resources in the instructional process (Alice, 2012). According to Busljeta (2013), orderly delivery of lessons, developing acceptable attitudes and values in learners, skill development, active engagement of learners in the teaching and learning process, and making lessons lively are some reasons instructors use teaching and learning resources in their lesson delivery. What is seemingly missing in literature is the reason of using teaching and learning resources because it is a requirement that instructors use these resources in lesson delivery.

Despite the benefits derived from using teaching and learning resources that teachers of mathematics are fully aware of and the fact that their usage is a requirement in some jurisdictions, literature is replete with the conception that many instructors do not engage these resources in their lesson delivery and more especially resources relating to technology. In a study conducted by Panthi and Belbase (2017), it was concluded that technological resources are barely used in the teaching and learning process. Mensah and Agyei (2019) came to the support of Panthi and Belbase when they conducted a study among some high school mathematics teachers and it was evident that teachers had a passionate love for the conventional method of teaching to the detriment of using the tools of ICT in their lesson delivery. Again, in a study conducted by Agyei and Benning (2015) among pre-service teachers to find out their use and perception of geogebra software in teaching mathematics, it appears many pre-service teachers are not aware of the geogebra software and that they (pre-service teachers) do not use the software because it requires much time and careful planning. More so, Affum (2001) made an observation that Ghanaian teachers make little or no use of appropriate teaching and learning resources in their lesson delivery. Adding to this discussion Salifu (2020) conducted a study at a college of education in Ghana to find out the effect of using GeoGebra in the teaching of plane geometry II; it came to light that teachers of mathematics do not actually integrate the tools of ICT into the teaching of geometry. It is becoming vividly clear that teachers do not use instructional resources in lesson delivery. Teachers' refusal to use instructional resources in their lesson delivery especially in teaching mathematics may be due to some pertinent barriers.

Several barriers do exist in teaching and learning of mathematics through the use of instructional resources. A study conducted by Onaifoh and Ekwueme (2017) recommended among other things in a study that computers should be adequately provided in schools, teachers should be trained on basic computing, provision of mathematical software and organisation of in-service training to teachers on how to use the software, to suggest that these resources and teachers' knowledge on their usage is limited. It is also noted that inadequate teaching and learning resources in general, inadequate technological resources and mathematics teachers' inability to use these resources effectively due to poor skills are other hindrances (Panthi & Belbase, 2017). On why teachers do no use GeoGebra software in teaching geometry, Molnar and Lukac (2015) reported from teachers that classes were over populated, teachers needed more time to plan the lesson using GeoGebra, teachers do not have the needed skills to use the software, students use much time to study the software and that the time required to use the software by teachers far out weights the benefits derived from its usage. Again, Alice (2012) noted from a study that most ICT tools were not available, those that were available were not adequate and not accessible as well, and the needed knowledge and skill to use them was limited. More so, the love for the conventional approach of teaching and inadequate training on the use of ICT tools appears to suggest why teachers of mathematics do not integrate technology into the teaching and learning of mathematics (Agyei & Voogt, 2012). The non-usage of teaching and learning resources by mathematics teachers according Fabiyi (2017) are among many factors leading to students' possible difficulties in learning plane geometry.

Gender Issues and Mathematics Achievement

The importance of mathematics cannot be overemphasised in any society. Based on this assertion the mathematics syllabus of Ghana was built to achieve one main rational, that is allowing all young Ghanaian persons to acquire the necessary mathematical skills, attitudes and values that they will need in their chosen professions and daily lives (CRDD, 2010). On this notion therefore, the mathematics syllabus summarised carefully the importance of mathematics based on the twin premise that everybody can learn mathematics and all need to learn mathematics. Following this, formal education in many countries has always made the attempt to create a levelled playing field for both females and males to study mathematics and its related programmes. Ghana for instance has mixed schools and mixed classes as well as single sex schools of both sexes. Education is opened to all sexes, tribes and religious groupings that one can attend school anywhere in any part of the country unrestricted. This assertion is well supported by the Computerised School Selection and Placement System (CSSPS). This system allows for the placement of qualified students into Senior High School almost in a random fashion. Career opportunities are as well opened to all sexes based purely on qualification. Both sexes in Ghana partake in the national Mathematics and Science Quiz a yearly ritual to improve the achievement levels in mathematics and its related fields of study. Also, schools that were considered non-performing in especially mathematics were identified and put under the Secondary Education Improvement Project (SEIP) programme with the aim of improving the learning outcomes in the critical subjects such as mathematics for both sexes.

Despite the effort put towards the study of mathematics by all societies and countries, there has been a huge public outcry about the low achievement levels in mathematics and its related programmes such as Science and Technology. Research is replete with the fact that learners are performing poorly in mathematics and its related fields of study (Asomah, Wilmot & Ntow, 2018; Serebour, 2013; Wilmot, 2001; Tay & Mensah-Wonkyi, 2018; Festus, 2013, Jameel & Ali, 2016). The apparent disparities in low achievement in mathematics and its related fields of study have been viewed with different lenses. These disparities are identified among different categories of schools (day and boarding) and gender (Amunga & Musasia, 2011). In a study conducted by Kiptum, Rono, Too, Bii and Too (2013), several factors relate to the achievement disparities in mathematics between females and their male counterparts at all levels. These include among others things parents' educational level, socio-economic status of parents and gender of learners.

The issue of gender and mathematics achievement is a mixed basket. There are those who believe that both sexes are competing favourably in mathematics and its related fields of study. Others still hold the notion that the domain of mathematics is a male dominant area and yet there are those who are painting the picture that the female has long overtaking the male counterpart in this important area of study. In other assertions, the disparity in mathematics achievement between females and their male counterparts is just a matter of time. Girls may be better at a point and their male counterparts will take over the baton and vice versa. In a study conducted by Uwineza, Rubagiza, Hakizimana and Uwamahoro (2018) in Rwandan secondary schools, it was observed that females normally outperform boys in school examinations in especially mathematics but will eventually be overshadowed by males in national examinations.

In a study conducted by Ghasemi and Burley (2019), they found that both sexes are of the view that the field of mathematics does not favour a particular sex in terms of achievement and its affect. Again, Smith (2014) made the assertion that mathematics achievement in the global stage is an equal ball game now. In another study conducted to find out differences in mathematics achievement and retention between females and males in their learning of algebra, it was found that both sexes pull parity in this direction and was concluded that females and their male counterparts can compete favourably in this branch of mathematics (Ajai & Imoko, 2015). In addition, a study conducted to find out the differences in mathematics achievement by gender in Ghana National College revealed that no such differences between male and female learners existed in the experimental group (Arhin & Coffoe, 2015). Again, when females and males partake in both national and school level mathematics quizzes, it is not always a win for girls (Tetteh, Wilmot & Ashong, 2018). In support of this claim, Tsui (2007) conducted a study in China and America to find out the achievement differences in mathematics between females and their male counterparts and it came out that disparities in achievement scores in mathematics between both sexes in China is non-existent. The seemingly equal achievement in mathematics in China is attributed to well trained professionals, career oriented designed curriculum, believe that achievement in mathematics is more of effort than innate characteristics and the influence of parents in gender-neutral form of education as highlighted by Tsui.

Researchers who are of the view that achievement disparities in mathematics and its related fields of study is a matter of time cannot be skipped. In a study conducted by Tommaso, Mendolia and Contini (2016), they observed that achievement gap in mathematics widens between both sexes as they grow. The difference seems to be faint at the lower levels of the academic ladder but widens in favour of males as learners progress higher in this journey of their educational life. This was supported by Mekonnen (2011) that the gap in favour of males becomes apparently visible from secondary school level. Again, literature reviewed by Brown and Kanyongo (2010) supported the claim that achievement disparities in mathematics is non-existent at the lower levels of formal education.

In other jurisdictions, the female has outperformed their male counterparts in those fields of study normally dominated by males. In a study conducted by Parajuli and Thapa (2017) on gender disparities on academic achievement, it came out that females far outperformed their male counterparts. They asserted that in the context of Nepalese, females are paid more attention and sympathy to by both culture and religion and that this may explain why they are doing better than their male counterparts in the critical subjects like Mathematics and Science. Also, a study conducted by Brown and Kanyongo (2010) in Trinidad and Tobago to find out the differences in mathematics achievement by gender, it was revealed that females actually had higher mean scores than boys which goes to suggest that higher mathematics achievement is actually in favour of females. Again, in domain specific areas like geometry in mathematics, a study conducted in Nigeria alluded to the fact that females performed better than their male counterparts in this area of mathematics (Fabiyi, 2017).

Notwithstanding, the above claims of putting females ahead of their male counterparts in the area of mathematics achievement, there are yet other researchers who are holding contrary views to these assertions. A study conducted by Smith (2014) indicated that males in general have upper hand when it comes to rotation and interpretation of geometrical objects. Again, a claim has been put out there that males are the masters when it comes to mathematics and its related fields of study (Science, Technology and Engineering) (Tommaso, Mendolia & Contini, 2016). Also, in Rwanda both male teachers and learners are of the view that the field of mathematics is dominated by males and that teachers will mostly likely teach in male dominated classes than those classes dominated by females (Uwineza, Rubagiza, Hakizimama & Uwamahoro, 2018). In a study conducted by Nganga, Mureithi and Wambugu (2018), they came to the confirmation that female learners are nowhere nearer to their male counterparts when it comes to achievement in mathematics and its related fields of study.

It appears the debate between females and their male counterparts on which group has a superior achievement outcome in mathematics and its related fields of study will not end soon. But, the emerging condition is that, there should be a deliberate attempt in helping both sexes who do not see mathematics as an option to come to terms with it. This is so because the success of everyone depends greatly on the knowledge of mathematics and its related fields of study. It does not really matter whether one is a high achiever in mathematics or not, what matters is the utilitarian value of mathematics for all. It is argued strongly that the world runs on good mathematical knowledge and mathematics is life and a key to a holistic personal development (Hodanova & Nocar, 2016). The utilitarian value of mathematics in society should explain why the debate between who performs better (girls or boys) in mathematics should be shifted to how to best help those who are performing poorly in the subject.

Though literature reviewed may not support one sex to be better than the other in terms of mathematics achievement, the picture been painted out there seems to suggest that many factors are still inhibiting the mathematics achievement of females and their choice of mathematics and its related fields of study as programmes to offer at the higher levels. Some researchers are of the view that culture and biological factors account largely for low achievement of females in mathematics. In a study conducted by Asante (2010), biological and cultural factors were identified as militating against high achievement levels of females in mathematics and its related fields of study. In this direction as suggested, some females as part of culture go into early marriages and yet some families rather spent heavily in educating the male child to the neglect of his female counterpart, and finally, females in most cultures are assigned roles in the family that gradually prepares them to be become housewives. Also, in a study conducted by Iwu and Azoro (2017), it was concluded that culture, gender labelling and poor instructional approaches are among factors that make females in general to shy away from the study of mathematics and its related fields of study. Again, Uwineza, Rubagiza, Hakizimana and Uwamahoro (2018) in a study revealed that, most females have low self-esteem to the study of mathematics and that females in general feel shy to ask questions in class whether they understand the concept or not. More so, in a study conducted by Tetteh, Wilmot and Ashong (2018), a picture was apparently painted that women mathematicians are considered by society as abnormal and or not marriage materials. The shocking revelation from that study conducted by Uwineza, Rubagiza, Hakizimana and Uwamahoro (2018) was also that most girls do not enrol in mathematics for a reason, to them a good mathematician will most probably be a teacher, but the teacher is the least valued in society. This further explains why female numbers keep reducing as learners' progress through the ladder of education in mathematics and its related fields of study. This current study will also look at gender issues and mathematics achievement.

Methods of Teaching Plane Geometry

The field of geometry is a complex area to teach and learn. Several methods are available and are used by teachers in their quest to helping students understand the concept of geometry. In a study conducted by Mollakuqe, Rexhepi and Iseni (2021), they identified the use of geogebra software and the classical method (where students construct the circle and its parts as does by the teacher on the board) as two ways of teaching and learning plane geometry. In the classical approach of teaching and learning geometry, the accuracy of the construction of the required circle and the subsequent solving of the geometrical problems largely depends on the skill of the student. The classical approach of teaching and learning is therefore, similar to the conventional (lecture) method with marker-board illustrations. Again, in a study conducted by Thompson (1992), he identified three methods such as learning through pencil and paper activities in small cooperative groups, learning geometry through the use of geogebra in small cooperative groups, and the conventional (lecture) approach through whole class instruction in teaching and learning. To Thomson, students learning through pencil and paper activities in small cooperative groups appear to have a higher positive effect on students' geometrical achievement. Also, Tay and Mensah-Wonkyi (2018) identified the lecture (conventional) method, the use of geogebra software, and the activity-based approach (measurement of angles) as the three methods relating to the teaching and learning of geometry. Therefore, three methods dominate literature pertaining to the teaching and learning of geometry as a field of study in mathematics. These are the conventional (lecture) method, the use of geogebra, and the activity-based approach of teaching and learning.

The conventional approach of teaching and learning dominates the other methods in the education of students in the field of geometry in particular and mathematics in general (Noreen & Rana, 2019). According to Weegar and Pacis (2012), behaviourists prefer conventional approach of teaching and learning because it presents the right medium for the instructor to pour out what he/she thinks is the right knowledge for the learner. In this approach, the teacher considers knowledge to exist externally and must be transmitted from an experienced fellow/teacher to the learner (Shah, 2019). The student remains a mere listener than a learner and a passive receiver of what the teacher has predetermined. In the field of geometry for instance, the teacher comes to state the rules and properties in solving geometrical problems compelling students to memorise these theorems without understanding (Salifu, 2020). Students therefore, do not interact, discuss and explore geometrical concepts and content collaboratively (Tay & Mensah-Wonkyi, 2018). The approach therefore, puts more emphasis on remembering of facts and not of thinking and reasoning as put forward by Tay and Mensah-Wonkyi, a more reason why many students have problems relating to learning of geometry and their subsequent failure in this domain of mathematics. This has propelled many educationists and researchers to look outside the brackets to other methods such as the use of geogebra software in teaching and learning geometry.

Geogebra is dynamic mathematics open-source software for teaching and learning geometry, algebra and calculus (Hohenwarter, Jarvis & Lavicza, 2008). The use of geogebra software as a teaching and learning approach involves students' hands-on activities and teacher-led demonstrations using GeoGebra, Tay and Mensah-Wonkyi. In this approach, lessons are carefully designed and held in the computer laboratory in order to help students to explore the concepts of Circle Theorems using computer. In the computer laboratory, students are taught circle theorems by using GeoGebra with worksheets which are designed hand in hand with the lesson plan according to activities in the Mathematics curriculum. For instance, the concept that opposite angles of a cyclic quadrilateral add up to 180° (are supplementary), can be proved with GeoGebra software by drawing a single circle with an inscribed quadrilateral and measuring and comparing the angles. When the various points of the quadrilateral are moved around on the circumference of the circle, the opposite interior angles always add up to 180. In this case, time is saved here and results obtained are accurate. Though it appears very easy to use the geogebra software in teaching and learning geometry, this has been debunked (Molnar and Lukac, 2015). These researchers are of the view that teachers possess inadequate knowledge and skills in teaching with geogebra, large number of students in our classrooms hinders its use, that both teachers and students need much time to plan and learn the programme respectively, and that the benefits of it do not actually much the time, resources and energy required in using the software. Again, in a study conducted by Agyei and Benning (2015), it was concluded that many pre-service teachers are not aware of the geogebra software in teaching and learning geometry and that it requires much time and planning to use it a reason many teachers stick firmly to the lecture method. Also, Agyei and Voogt (2011) in a study asserted that there are no such opportunities for teachers in the use of ICT in the classroom, that the appropriate ICT infrastructure is not available in schools, and teachers do not use ICT in the classroom because they do not possess the required skills, and that courses are not designed for technology integration. Therefore, in this era of non-existence of computer laboratories and mathematical software in our schools, large number of students in the classrooms and inadequate skills in the use of geogebra in teaching and learning geometry, there is the need to rely on a more reliable method that stand the test of time-the activity-based approach.

The Activity-Based Approach for Teaching and Learning Geometry

Adu-Gyamfi (2014) sees the activity-based approach of teaching as a learner-centred approach of teaching mathematics and its related programmes where teaching and learning resources are provided for learners to interact with the aim of discovering concepts, principles and facts about mathematics with little or no support from instructors. To Adu-Gyamfi (2014), activity-based teaching approach is the preferred choice to teaching and learning mathematics and its related fields of study because it enhances learners' achievement and retention in mathematics. Through the activity-based teaching approach, learners can easily adjust their prior knowledge to accommodate successfully the learning of new concepts. No wonder this approach of teaching and learning mathematics has gained favour in the eyes of the 2019 mathematical curriculum developers of Ghana. In the curriculum, hands and minds-on activities are suggested to be used by mathematics instructors in the teaching and learning process so that learners can study mathematics with fun and as part of culture (NaCCA, 2019).

Tay and Mensah-Wonkyi (2013) are of the view that the activity-based teaching approach creates for both the instructor and learner a platform to participate in almost an equal measure to the teaching and learning of geometry in particular and mathematics in general. In our part of the world where ICT tools and mathematical software such as GeoGebra are not readily available and accessible to mathematics instructors coupled with their inadequate knowledge and skills in the field of technology, they have no option than to be innovative (Molnar & Lukac, 2015; Alice, 2012). The activity-based teaching approach has proven itself to be a reliable teaching method that can fit well into teaching and learning geometry in particular and mathematics in general. In a study conducted by Adu-Gyamfi (2014), he found out that the experimental group taught with the activity-based approach actually performed better than those learners taught through the conventional approach of teaching. To Festus (2013), the concepts and properties of plane geometry II (circle theorem) can actually be taught well through the activity-based teaching approach in the absence of the GeoGebra software where worksheets can be created for students in groups to measure the various angles and discuss to discover for themselves all the properties. In this way the instructor will be spared the trouble of having to talk more but reaping little from learners' mathematics achievement and the knowledge gained in the process can successfully be applied to other related areas of the subject such as construction. But many instructors appear not to be aware of this teaching approach in the teaching and learning of plane geometry in particular and mathematics as a whole compelling them to develop a deep love for the conventional approach to teaching mathematics and its related programmes as do in social studies classes.

In a conference paper presented by Hodanova and Nocar (2016), on the importance of mathematics in our lives, it was concluded that teaching approaches that will actively engage the learners in the teaching and learning process should be encouraged. It is their view that when learners participate actively in the teaching and learning process, they will have a better understanding of mathematical concepts and can apply this in related fields of study. To Ilyas and Saeed (2018), the activity-based teaching approach is a better platform for learners to identify and remediate misconceptions that they previously hold. There is therefore, relational learning and conceptual understanding of concepts of mathematics and achievement in the subject. When activity-based teaching approach is used in the teaching and learning situation, both the instructor and the learner actively engage in the process, learners are able to discover knowledge and facts for themselves and therefore retention and recall are better achieved with this approach of teaching (Festus, 2013).

The merits of the activity-based teaching approach include among other things development of leadership skills, better learning of mathematics and creativity, team work and all the benefits associated with it (Pokhrel, 2018). To Pokhrel (2018), activity-based teaching approach should be every instructor's target since it develops in learners' deep understanding of mathematical concepts and skills as well as positive attitudes and values towards the study of the subject. But building conceptual understanding of mathematical concepts and developing in learners positive attitudes and values in the study of mathematics is the aim of mathematics education (CRDD, 2010). To this end, National Council of Educational Research and Training (2005) has stretched the need to teach and learn mathematics through carefully planned activities from the very foundation of formal education. Unal (2017) believes also that hands and minds-on activities are non-negotiable in the teaching and learning of mathematics and its related fields of study since these domains of learning are practical in nature. Active participation of learners in mathematics and its related fields of study according to Unal (2017) is a valuable thing to do in the teaching and learning situation. Effective mathematics teaching and learning appears to be better achieved through hands and minds-on activities where learners can actively participate in the instructional process. According to Pokhrel (2018), when the activity-based approach of teaching and learning makes use of the method of cooperative learning, it develops in learners different skills such presentation, coomunication and leading group activies.

Cooperative learning strategy is a method of learning which emphasises students learning through collaboration (Vakilifard, Bahramlou & Mousavian, 2020). To Yu and Yuizono (2021), cooperative learning strategy uses the principle of individual knowledge construction but as a function of group participation. To Altun (2015), the cooperative learning strategy is built on such principles as social skills development, face-to-face interaction of students, positive interdependence and individual accountability. Also, Yu and Yuizono believe that cooperative approach of learning enables students to work together with a common goal. Vakilifard, Bahramlou and Mousavian

(2020) are also of the view that cooperative learning develops in learners such social skills as communication, appereciation and coexistence.

Several benefits accrue to the usage of the cooperative learning strategy in learning especially mathematics. Altun (2015) believes that in this era of information rich society, the most important skill is the ability to share information through cooperative learning. To Altun, having different perspectives about learning, developing a great sense of responsibility and social skills as well as ensuring permanent knowledge creation are some benefits of the cooperative learning strategy. Again, social support where weak students can learn from peers, reduction in anxiety, critical thinking and active involvement in the learning process are other benefits of the cooperative learning strategy (Laal & Ghodsi, 2011)). According to Vakilifard, Bahramlou and Mousavian (2020), the success of one student in the group can lead to the success of the whole group and also that the more capable learners can help the weak ones to learn effectively the intended concepts. Hagan, Amoaddai, Lawer and Atteh (2020) suggested therefore, that the cooperative learning strategy should be used to help develop students' interest in studying mathematics, improves understanding of mathematical concepts and topics, and remove negative perceptions of students towards the study of the subject.

According to Laal and Ghodsi (2011), there are three possible scenarios that can arise in the usage of cooperative learning strategy that are worthy of understanding. Students can work towards achieving a common goal, they can work against the achievement of the common goal and finally, students can individually work to achieve goals that are not actually related to the targets of the general group. In this direction therefore, care must be taken when using the cooperative learning strategy.

Despite the benefits emanating from the use of the cooperative learning strategy, there can be some disadvantages of using this approach if the process is not properly managed. Students may harbour the fear of being withdrawn from the group if they are suspected to be contributing to the downfall of it and also the idea that all the group members must succeed may negatively affect other members (Altun, 2015). It is also possible that fast learners may overshadow the weak ones and the group's aspirations may not be realised. When this happens, the perception of incorporating cooperative learning strategy into the activity-based approach of teaching and learning to harness the benefits of it will fail.

Perceptions of Students towards the Activity-Based Approach of Teaching and Learning

The opinions and views students hold about the teaching and learning process, a subject, an activity or a concept constitute perception. Perception of students towards mathematics, an activity and or the teaching methods teachers use in their lesson delivery are important determiners of whether students will succeed or not. According to Wasike, Michael and Joseph (2013), students' perceptions towards mathematics in general are among the many notable factors that influence their performance in the subject. To Hagan, Amoaddai, Lawer and Atteh (2020), students show both positive and negative perceptions towards the study of mathematics. According to these researchers, though students may exhibit some positive or negative perceptions towards the study of mathematics, the academic performance in the subject among Senior High School students in Ghana is significantly not predicted by these. But Wasike, Michael and Joseph (2013) are of the view that positive perceptions of students towards the study of mathematics are influential determinants to improving performance in the subject. They are therefore, suggesting that the negative perceptions female students hold towards the study of mathematics consequently lead to their poor performance in the subject. In a study conducted by Arthur, Asiedu-Addo and Assuah (2017), they found out that negative perceptions of students in general affect negatively the interest of students in studying the subject mathematics. They therefore, suggested that, teaching methods such as activity-based approach should be used in teaching and learning of mathematics to motivate students in order to reduce the negative perceptions they have towards the study of the subject. According to these researchers, the perception of some students out there is that teachers do not involve them in the teaching and learning process and therefore, only bright students perform well in mathematics.

In a study conducted by Albadi (2019) to find out the impact of the activity-based approach of teaching on students' achievement, it came out that students in general have positive perceptions towards this approach. Specifically, students have the perception that, the activity-based approach of teaching and learning enhances understanding, improves students' achievement, helps weak students to develop, it encourages the creation of interesting teaching and learning atmosphere and cooperative learning. Again, the activity-based approach of teaching and learning in the view of students encourages the creation of active learning environment, leads to conceptual understanding of concepts, creates interest towards learning and it is an interesting and useful method for learning in general (Parekh, Munjappa, Shined & Vaidya, 2018).

Theoretical Framework

Educational researches are almost always grounded on theories of learning. In this study, constructivism as a learning theory provided the basis for conducting and reporting on the findings. Constructivism as a theory of learning is in direct opposition to behaviourism which chalked some successes before it (Bada, 2015). To Shah (2019), constructivists are opposing the idea that the mind of the learner is a blank slate that needs an experienced person to scribble the needed material on it. Constructivism as a school of thought evolved slowly over time. The journey to constructivism started from behaviourism then to cognitivism (Jia, 2010). Constructivism as learning theory believes that learning is better achieved when learners are allowed to actively partake in the instructional process with the aim of constructing their own knowledge and this marks the point of departure from behaviourism where knowledge is perceived to be external that must be transferred to the learner (Nabie, 2000). Constructivism gave explanation to how learners construct knowledge and how they learn (Bada, 2015). To the constructivists, knowledge construction and making of meaning are based on experiences (Dagar & Yadav, 2016) and that knowledge is developed through active participation (Weegar & Pacis, 2012). Therefore, constructivists' knowledge construction is emphasised on four aspects to include encouraging knowledge construction and not transmission of knowledge, allowing prior knowledge of learners to play an active role in the construction of new knowledge and creation of knowledge through social interaction (Dagar & Yadav, 2016).

The constructivists theorem can be dichotomised into two; radical constructivism and social constructivism (Liu & Chen, 2010; Liu & Matthews, 2005). Others agreed that the proponent of radical constructivism is Ernest von Glasersfeld and that of social constructivism is Vygotsky (Liu & Chen, 2010). Yet, others considered Piaget to be the proponent of radical constructivism and Vygotsky the father of social constructivism (Liu & Matthews, 2005). Radical constructivists' tradition focuses on the individual learner and adopts methods such as experiments, case studies and interviews in its teaching and learning situation (Selden & Selden, 1996). It begins with the individual, but creates room for interaction and communication. The contribution of radical constructivism is that teaching and learning do not happen magically but must be skilfully planned. Questions regarding the nature of individual mathematics construction must be integrated with questions concerning the initiation of that individual into the mathematical community. To the radical constructivists, learner-centred approaches such discovery learning should be encouraged and that social environment and interaction are merely stimulus in nature (Liu & Matthews, 2005). This believe of the radical constructivists that interaction between members in a learning group or community is merely stimulus differentiated them from social constructivists.

Social constructivists' tradition focuses on group dynamics that is the relationship and interaction between the learner and the larger mathematics community. In understanding mathematics learning better according to the social constructivists', culture and social dimensions of the classroom must play an active role in the teaching and learning process (Selden & Selden, 1996). Vygotsky (the proponent of social constructivism) believes as others do that learning is better achieved with guidance from an adult/teacher or more capable peers and that knowledge construction involves naming, comparing and defending ideas or discussion (Dagar & Yadav, 2016). Vygotsky characterises the learner's development in terms of shifts in control or responsibility. The possibility of shifts is then diagrammatically represented in Figure 6 by the three concentric circles in his zone of proximal development:

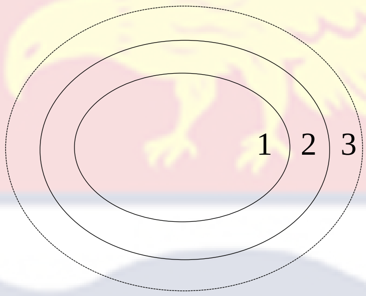


Figure 6: Vygotsky zone of proximal development

Zone 1 is where the individual can reach studying alone; zone 2 represents where the individual can reach studying with an adult or more capable peers and zone 3 the region of which both the individual and the adult or more capable peers cannot reach studying together. The difference between the learner's development working alone and that of his/her potential development working with adult or more capable peers is that zone of proximal development (Shabani, Mohammad & Ebadi, 2010). The more competent participants according to Vygotsky will guide the interactions so that learners can participate in activities that they could not manage by themselves. This helps learners to increase their control and responsibility. The zone of proximal development by Vygotsky was to criticise the way all Russian schools at the time carryout psychometric-based testing. This traditional testing only reflected the current achievement levels of learners rather than their future potential development (Shabani, Mohammad & Ebadi, 2010). To the social constructivists the teacher's ability to relate mathematical ideas to the life experiences of the student is the most crucial goal (Prideaux, 2007). Therefore, social constructivists believe in active engagement of students in the teaching and learning process through enquiry method, problem solving approach and collaboration between teachers and learners, and also between students and peers, as put forward by Prideaux.

Social constructivists' ideas and principles are among the most cited in psychology and education in recent times and many researchers and scholars therefore, ground their works in social constructivism (Knapp, 2019). This gives a justification why the activity theory as embedded in the works of Vygotsky and his associates is deeply rooted in social constructivism (Hasan & Kazlauskas, 2014). The activity theory is grounded in social constructivists' principles and ideas because it provides the right medium for learners to discuss, reflect and share ideas thereby enhancing better understanding of mathematical concepts, Knapp (2019). The activity theory is rooted deeply in almost a century of scientific research and has a rich application in many fields of study such as mathematics education. According to Hasan and Kazlauskas (2014), the activity theory denotes the performance of a particular action, how it is performed, and the purpose for which the said action is carried out. As a theoretical framework, the activity theory helps in analysing and understanding human interaction through the use of some appropriate tools (Hashim & Jones, 2014). The Activity-Based Approach of teaching and learning as theorised in this study is situated in the activity theory which underpins social constructivists' core ideas of teaching and learning as symbolised in figure 7.

Learner (Student) → Task (Activity) → Product (Outcome)

Figure 7: Core idea contained in activity theory

Figure 7 fitted properly the current study in that, the learner was presented with series of activities to perform. This led to an improved conceptual understanding, remediation of misconceptions and positive perceptions towards the study of plane geometry. The outcome then became the improved achievement in mathematics in general and plane geometry in particular.

Conceptual Framework

A sizeable number of research outcomes have identified a positive correlation between the activity-based approach of teaching and learning and development of positive attitudes towards the study of mathematics and students achievement in the subject (Noreen & Rana, 2019; Unal, 2019; Pokhrel, 2018; Celik, 2018). It is in the light of this that, social constructivists align themselves to the activity-based approach of teaching and learning (Hasan & Kazlauskas, 2014; Ilyas & Saeed, 2018; Albadi, 2019; Knapp, 2019). From the foregoing review, the conceptual framework was developed by the researcher as indicated in figure 8 to underpin the study.

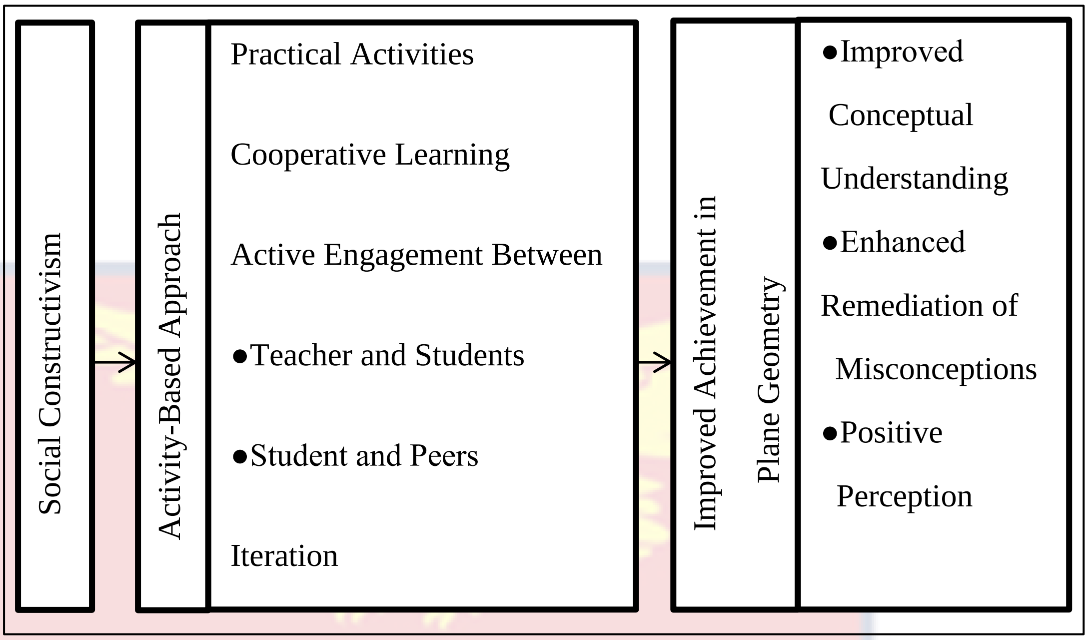


Figure 8: Teaching and learning through activity-based approach

The study posited that when activity-based approach of teaching and learning which is characterised by practical activities, cooperative learning, active engagement and iteration is properly carried out, it will lead to an improved achievement in plane geometry measured by improved conceptual understanding, enhanced remediation of misconceptions and positive perception towards the activity-based approach of teaching and learning.

In this study, the activity-based approach of teaching and learning plane geometry allowed for active engagement on hands-and minds-on activities such as identification, measuring and comparing angles, social interaction and sharing of ideas. These activities were carried out in groups of two (through cooperative learning) so that students could engage actively in the teaching and learning process. There was therefore, active collaboration between the teacher and students and also between the student and peers in the teaching and learning situation. Cooperative group activity is necessary to promote the needed interaction between students and their peers (Hashim &

Jones, 2014). Through cooperative learning the students were encouraged to ask questions, explain and justify their opinions, articulate reasoning and reflect upon the knowledge acquired. This led to iteration where students were encouraged to express their ideas and also get timely feedback from the facilitator. Well organised activities provided the right medium for learners to think deeply on the critiques they received through whole class discussions, made the required adjustments, and tried again if the need be. In this way, the activity-based approach of teaching and learning led to improved achievement in plane geometry.

Improved achievement in plane geometry was measured by improved conceptual understanding, enhanced remediation of misconceptions, and positive perception towards the study of mathematics, and the activity-based approach of teaching and learning. According to Al-Mutawah, Thomas, Eid, Mahmoud and Fateel (2019), the learner’s ability to reason logically and comprehend mathematical concepts, relations and operations which can be applied in solving unfamiliar problems refers to conceptual understanding. Verkade et al (2019) believe that conceptual understanding can only take place under at least two situations. In one situation, learners may have accurate but incomplete prior knowledge of a concept. In this case, the learning process should be geared towards filling the gaps in students’ understanding of the concepts with accurate knowledge. In the second situation, a learner comes to class with prior knowledge that is in conflict with what is to be learnt. This situation calls for evaluation, revision and replacement of the improper prior knowledge with thoughts that are in consonant with the new concept to be learnt. When mathematical concepts are misconstrued, it leads to development of misconceptions. Misconceptions are wrong notions that are developed about a concept which can hinder the smooth teaching and learning of the subject (Waluyo, Muchyidin & Kusmanto, 2019). Ojose (2015), sees misconceptions to be erroneous understandings and misinterpretations conceived by learners based on ill-information. One way of helping students to learn mathematics better is to change their perception towards the study of the subject. The opinions and views students hold about the teaching and learning process, a subject, an activity or a concept based on experiences constitute perception (Wasike, Michael and Joseph, 2013). These researchers are of the view that perceptions of students towards mathematics in general are among the many notable factors that influence their performance in the subject. To Hagan, Amoaddai, Lawer and Atteh (2020), students show both positive and negative perceptions towards the study of mathematics. To Wasike, Michael and Joseph (2013), positive perceptions of students towards the study of mathematics are influential determinants to improving achievement in the subject.

In this study, improved conceptual understanding, identification and enhanced remediation of misconceptions, and positive perception towards the study of geometry gave explanation to improved achievement in plane geometry. Improved conceptual understanding and enhanced remediation of misconceptions were measured through the qualitative and thematic analysis of both the pre-and post-achievement tests results of students. The perception towards the study of geometry and the activity-based approach was measured by students' perception questionnaire. Focus group discussion on questions relating to conceptual understanding, identification and remediation of misconceptions, and students' perception towards the study of geometry was as well carried out. There was an observational guide purported to identify the challenges students go through in measuring angles, their conceptual understanding of geometrical concepts and misconceptions. The results of the focus group discussion and that of the observational guide served the purpose as to support the main quantitative findings.

Specific application of Activity-Based Approach (ABA) in the Study

In summary, Table 1 recapitulates the components or factors of Activity-Based Approach of teaching and learning using social constructivists' principles and ideas as operationalized in the study. It presents the factors of the Activity-Based Approach; what or who they represent and how they can be identified in the study.

Table 1: Specific application of Activity-Based Approach (ABA) in the Study

Step	Teacher (T): Task	Students (Ss): Task	Interaction	Purpose
1	Introduction, lesson pre- test	Listen, answer the pre-test	T <> Ss	Arouse interest, stimulate background knowledge
2	Pair students with the help of the class teacher taking note of ability grouping and gender, also give students the worksheets.	Form small groups, familiarise themselves with the worksheets	T <> Ss	Trigger participation, allowing weak students to also benefit in the activity
3	Ask students to identify and measure the various angles as contained in the worksheets, and record their answers, go round and observe.	Students actively engage in the activity using the worksheets and protractor.	T assists Ss who have difficulties in identifying, measuring and reading the angles.	Assist students to accurately identify, measure, and read the required angles
4	Ask students to	Students share	T and Ss	Determine the

	share their results item by item	their results orally and also through marker board presentations	discuss through question and answer method to identify the various theorems, properties and rules	various theorems and properties
5	Ask students to answer the questions on the worksheets (lesson post-test)	Students in their groups answer the questions	T and Ss discuss the questions and their required answers	Determine students' conceptual understanding and misconceptions
6	Ask students what they have learnt in the lesson and how the next lesson can be delivered	Students demonstrate their understanding of the concepts learnt by giving explanations	T asks Ss to work on the next sub-topic for subsequent discussions	Summarise the lesson

The purpose of this activity was to use social constructivists' ideas and principles through the Activity-Based Approach (ABA) as a tool in helping students to construct their own knowledge. The use of the Activity-Based Approach (ABA) helped students to acquire and share knowledge thereby increasing active participation and interest in the activities. This led to improved conceptual understanding, enhanced remediation of misconceptions and development of positive perception towards the study of geometry and the subsequent improvement in students achievement.

Chapter Summary

This chapter focused on reviewing literature adjudged to be relevant to the study. Literature was reviewed on the nature of geometry, gender issues and mathematics achievement and the activity-based approach of teaching and learning. The activity theory as the aspect of social constructivism operationalized in the study served as the foundation on which the current study was built. Social constructivism depicts learning to be a social activity involving more than one person. Activity theory explained the relationship between elements or factors necessary for a successful interaction. The conceptual framework for the study was subsequently developed based on the tenets of social constructivism and discussed.

CHAPTER THREE

RESEARCH METHODS

Overview

The purpose of this study was to investigate the effectiveness of Activity-Based teaching approach (ABA) on students' achievement in plane geometry. This section of the study provided detailed description of the methodology which was used in the study. This included the research design, study area, population, sample and sampling technique, research instruments, data collection procedure and the method (s) of data analysis.

Research Design

The concurrent embedded design was employed in this study. The concurrent embedded design is characterised by collecting both quantitative and qualitative data at the same time (Creswell, 2012). The qualitative data is set out to explain or support the quantitative data. Creswell (2012) is of the view that though the supporting data can also be quantitative in nature, using qualitative data to support the quantitative form of data is the most cited in literature. The quantitative data seeks to explain whether the intervention had any impact on the outcomes and the qualitative form of data assessed how participants have experienced the intervention. In this research, the primary quantitative data were the pre-and post-achievement tests results of students and the students' perception questionnaire. The supporting sets of data were the qualitative analysis of the pre-and post-achievement tests results, responses from the focus group discussions, and results from the observational guide. The advantage of this design is that it gives an in-depth understanding of the problem at hand to the researcher (Creswell, 2012). The challenges may be that the intent of the secondary data may not be clearly stated, combining the two forms of data may be a problem since they seek to address different research questions, collecting the two forms of data simultaneously may be labour intensive for a single researcher and embedding the secondary data may have an influence on the results of the experiment and vice versa. In this research work, the qualitative data was not purported to answer a separate research question but to augment the quantitative findings. The pre-achievement test was first conducted followed by the observation, the post-achievement test and the focus group discussion. Therefore, if a student was not able to answer the test questions, he/she may conclude that the activity-based approach of teaching is not appropriate for teaching and learning and vice versa.

Study Area

Both the control and experimental schools are situated in the Upper West region of Ghana. The two schools are located in two different administrative districts separated by approximately 42 km. These schools are both in category A of the Ghana Education Service (GES) categorisation of schools. There are thirty senior schools in the region out of which three are category A and the rest are either category B or C. The category A schools are relatively well resourced than the other category of schools. This reason necessitated the researcher’s choice of the category A schools to be involved in the study.

Research Population

The population of the research comprised form two core mathematics students of the 2022 academic year in the two selected districts in the Upper

West region of Ghana. Only form two students were used because the knowledge of plane geometry (I) in form one which was needed to teach plane geometry (II) in form two were both not treated yet because of the corona virus. It was then suggested by the head of departments (HoDs) of both schools that both plane geometry I and II be treated together in form two.

Sampling Procedure

The entire category A schools in the Upper West region were purposively sampled to be involved in the study. The reason for purposively selecting only the category A schools was that, these schools are relatively well resourced in terms of human (teachers) capital and material resources than the other category of schools. The category A schools therefore, possess the characteristics to be studied. The simple random sampling was subsequently adopted in selecting two participating category A schools (A and B) and one intact class each with similar characteristics from both schools. Intact classes were used to avoid regrouping of students and the challenge of discrimination, and to allow the research to go on during classes' hours. School A runs on four programmes: Home Science, Business, General Arts and Science. There are twelve (12) form two intact classes in school A consisting of 4 Home Science, 3 General Arts, 2 Business and 3 General Science. School B has eight (8) intact classes with 3 each of General Arts and pure Science and 2 Business. Folded strips of equal shaped paper with the eight (8) intact classes excluding Home Science were presented to the head of department of school A to pick one. Home Science was excluded because School B does not offer this programme. This was to ensure that the rest of the form two classes in school A had equal chances of taking part in the study.

The General Arts 2A class was chosen. This class then subsequently took part in the study. Based on this outcome in school A, the General Arts 2A class in school B was purposively selected to partake in the study. This action was to make sure that fairness is guaranteed when comparing the performance of the two intact classes in the post-achievement tests. In all 84 students made up of 47 (20 boys and 27 girls) and 37 boys respectively from school A and B took part in the study.

Map for the study

Form two students of the two intact classes of the two selected schools were first pre-tested to have an overview of their conceptual understanding and misconceptions on theorems and principles relating to plane geometry. The Activity-Based Approach (ABA) as an instructional tool was then employed to teach students in school A and the Traditional method (Tm) used in school B. In all, six lessons that covered senior high school plane geometry were taught in each school. The same lessons were taught in schools A and B with the exception of the mode of delivery. Whiles school A was taught through the Activity-Based Approach (ABA) where students identified, measured, and compared angles and using worksheets as the teaching-learning materials (TLMs), school B was taught in the usual teacher-centred teaching approach (traditional method) without the necessary activities and worksheets. Students of school B were therefore given the rules and theorems of plane geometry to memorise and subsequently use that to answer questions. They were also allowed to ask questions on theorems and principles they did understand. Lesson 1 covered issues relating to the triangle and parallel lines, lesson 2 covered quadrilaterals, and cyclic quadrilateral was treated under lesson 3. Also, lessons 4 and 5 covered chord theorems. Finally, lesson 6 covered theorems relating to the tangent. Each lesson covered two (2) hours making a total of twelve (12) hours for the six lessons in each of the two (2) schools. The period of teaching was six (6) weeks, three weeks each in both school A and B. After the intervention, both school A and B were again post-tested on same questions parallel to the pre-achievement test on theorems and principles relating to plane geometry. The process is illustrated as shown in Figure 9.

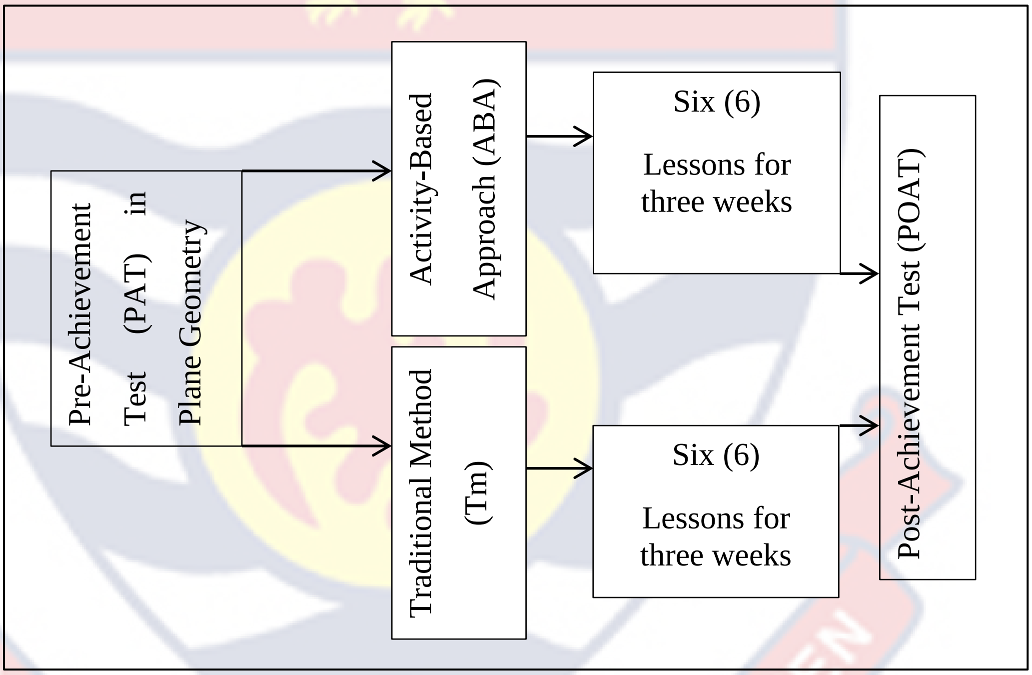


Figure 9: Map for the study

The study map presented two set-ups. The first set-up studied the experimental group which consisted of students taught through Activity-Based Approach (ABA). In the first set-up, comprehensive lesson notes covering six different lessons on plane geometry were developed and used to teach school A with the accompanying worksheets. This covered a total duration of three weeks. The second set-up studied the control group which consisted of students taught through the Traditional method (Tm). In the second set-up, lesson notes that covered the six lessons were also developed and used on students of the control group based on the dictates of the traditional method of teaching and learning. Students were therefore, taught through this method without the necessary teaching and learning activities and worksheets. Teaching was therefore, dominated by the teacher trying to explain the theorems to students as they sat down to listen. It also covered a total of three weeks.

The Variables Studied

The study explored the Activity-Based Approach (ABA) and the Traditional method as two approaches of teaching and learning plane geometry in senior high school core mathematics. This was carried out with the aim of realising the effect of the two approaches of teaching relating to the achievement of students in learning plane geometry in the teacher-constructed achievement test.

In this study, three variables were observed to include achievement of students in a teacher-constructed achievement test, perception of students towards ABA, and teaching approach. Teaching approach was categorised into Activity-Based Approach (ABA) and the Traditional method (Tm). The independent variable was the teaching approach whiles the two dependent variables were the achievement of students in the teacher-constructed achievement test and their perception towards teaching and learning with Activity-Based Approach. Achievement of students as one of the dependent variables was measured on an interval scale and perception, the second dependent variable was measured on an ordinal scale.

Data Collection Instruments

The following research instruments were used for data collection: pre- and post-achievement tests, questionnaires, focus group discussion, and observational guide. The pre-and post-achievement tests as well as the questionnaires were used to collect quantitative data and the qualitative data were collected using focus group discussion and observation. The detailed description of these data collection instruments has been catapulted in the succeeding paragraphs.

Pre- Achievement Tests

Self-developed pre-achievement tests (general and lesson pre-achievement tests) were constructed and conducted on the study participants. The items on the general pre-achievement test were constructed based on lessons to be covered and the objectives as contained in the Senior High School (SHS) core mathematics curriculum. Lesson pre-achievement test covered the objectives of the specific lesson to be taught. This was done before each lesson to get information on students understanding on the concepts to be learnt. The general pre-achievement test contained five essay type questions on plane geometry. Each question carried 8 marks making a total mark of 40. The nature of the test was decided on to avoid guesswork since the main purpose of the test was to measure students' conceptual understanding and identification of misconceptions. All the five questions were made compulsory and were answered by all students within a 60 minute period. The questions were made compulsory to avoid the challenge of having to compare students' results across different questions. As a covariate, the pre-achievement test was purported to help measure the effect of the intervention on students' conceptual understanding and remediation of misconceptions. The validity of the instrument was ensured by subject experts and the research supervisor. To guarantee reliability of the research instrument, the test was administered in two Category (A) schools without intervention. Also, reliability on the perception of students towards the activity-based approach of teaching and learning plane geometry was tested on alpha (α) = 0.05. Ensuring reliability in a research work is as important as ensuring validity (Bashir, Afzal & Azeem, 2008). The research work should be reliable in order for people to have faith in the results and conclusions of your work. In the same direction, Fisher (2007) categorised the coefficient of reliability into less than 0.67 as poor, 0.67-0.80 as fair, 0.81-0.90 as good, 0.91-0.94 as very good, and finally, above 0.94 as excellent.

Post-Achievement Tests

Self-developed post-achievement tests (general and lesson post-tests) were constructed and conducted on the study participants. The items on the general post-achievement test were constructed based on all the lessons covered and the objectives as contained in the Senior High School (SHS) core mathematics curriculum. Lesson post-tests were however developed and conducted on the study participants after each specific lesson delivered. The general post-achievement test instrument contained five essay type questions on plane geometry. Each question was also marked out of 8 marks making a total mark of 40 for the five questions. These questions were parallel to the general pre-achievement test items. This means that something small was changed on the pre-achievement test items to get the post-achievement test, though measuring the same concept. The nature of the test was decided on to avoid guesswork since the main purpose of the test was to measure students' enhanced conceptual understanding and enhanced remediation of misconceptions. All the five questions were made compulsory and were answered by all students within a 60 minute period. The questions were made compulsory to avoid the challenge of having to compare students' results across different questions. The validity of the instrument was ensured by subject experts and the research supervisor. To guarantee reliability of the research instrument, the test was administered in two Category (A) schools after the intervention. The purpose of this post-achievement test was to provide the basis to conclude whether there was an increase or otherwise on students' achievement after the intervention as well as determine whether the increase or decrease correlated with students enhanced conceptual understanding and enhanced remediation of misconceptions.

Questionnaire

This instrument facilitated the researcher to collect data on students' perception towards the Activity-Based Approach (ABA) of teaching and learning plane geometry. There were eighteen (18) questions on the instrument purported to answer the research question "What perceptions do students hold about the activity-based teaching approach in learning plane geometry?" Students of the experimental group responded to the questionnaire. The instrument was in two parts: introductory section and eighteen (18) questions adapted from Agyei (2012). The instrument developed by Agyei (2012) contained 29 items and this current study modified and adapted 18 of these items because of the similarities that existed between the two studies. Some of the items on his instrument such as item number 11 (The use of the simulation and the power point presentation motivated my learning) were excluded from the perception instrument of the current study because they did not fit the purpose. The instrument adapted sought to gather data on the views and experiences of the students in learning through the Activity-Based Approach (ABA) of teaching and learning plane geometry. The introductory part of this current study sought the consent of the learners and also assured them of confidentiality and anonymity. This introductory section was then followed by the eighteen (18) questions for students to respond to. The perception of students learning plane geometry through the activity-based approach was measured on four subscales: interest, comprehension, content delivery and usage. As operationalized in this study, interest refers to the student's disposition towards the activity-based approach of teaching and learning plane geometry, comprehension concerns itself with whether students understood the geometrical concepts and can apply them, content delivery was about how the teaching and learning activities were organised and taught. Usage also concerns itself with using Activity-Based Approach (ABA) to teaching plane geometry, mathematics in general and other subjects.

Focus Group Discussion Guide (FGDG)

A self-developed focus group discussion guide was constructed and conducted on the study participants. Four (4) participants took part in the focus group discussion. The instrument facilitated the researcher to collect data on students' perception towards the Activity-Based Approach of teaching and learning. The FGDG sought to gather data on the views and experiences of the students in learning through the Activity-Based Approach of teaching and learning plane geometry. The introductory part of the instrument sought the consent of the learners and also assured them of confidentiality and anonymity. This introductory section was then followed by 5 items for students to respond to.

The focus group discussion guide was purported to be used to collect qualitative data to support the main quantitative findings. It further considered the perception of students towards the Activity-Based Approach (ABA) of teaching and learning, students' conceptual understanding and misconceptions in learning plane geometry, and the challenges they encountered learning through this approach. It contained open-ended statements that helped the researcher to address the aforementioned purported areas of the instrument. The nature of the instrument allowed for worthwhile discussion, encouraged learners to express themselves and permitted the researcher to have an in-depth account of students' views and perception of learning through Activity-Based Approach (ABA). The facial and content validity of the instrument were determined by the supervisor who is a senior lecturer at the Department of Mathematics and ICT Education. Reliability of the students' perception questionnaire was tested on Chronbach's alpha (α) = 0.05.

Observational Guide

A self-developed observational guide was constructed and conducted on the study participants. The instrument facilitated the researcher to collect data on students' based on the Activity-Based Approach of teaching and learning. The instrument sought to gather data on identification, measuring, reading and interpretation of angles of plane geometry, and students' challenges in learning through the activity-based approach. The observational guide was purported to be used to collect qualitative data to support the main quantitative findings. It further considered the students' conceptual understanding and misconceptions in learning plane geometry. It contained both closed and open-ended statements that helped the researcher to address the aforementioned purported areas of the instrument. The nature of the instrument permitted the researcher to have an in-depth knowledge of students' learning through Activity-Based Approach (ABA). The instrument contained 18 items. The facial and content validity of the instrument were determined by the supervisor who is a senior lecturer at the Department of Mathematics and ICT Education. According to Kawulich (2012), in understanding further a situation under study, observation provides a useful tool to the researcher. The field notes collected that summarise observations are a good source of a detailed description of the situation observed.

Data Collection Procedures

The researcher first sought permission from the Department of Mathematics and ICT Education, the supervisor and the Institutional Review Board (IRB) of the University of Cape Coast of the researcher's intention to collect data for the study. Introductory letters from the Department of Mathematics and ICT Education were then sent to the two participating schools after a visit was made by the researcher to familiarise himself with the environment, teachers, as well as the students of the two intact classes chosen to partake in the study.

The study ran for six weeks. The teaching timetable of the two schools revealed that for every week there were four periods (that is two combined periods) for core mathematics. This means that a lesson was made up of one combined two periods making it two lessons per week. So, the six lessons were taught within three weeks. On day one of the study, the participating classes were briefed about the study and their consent to participate in it was sought. The pre-achievement test was then administered. The experimental group school A was introduced to the dictates of the activity-based approach of teaching and learning. The guidelines and responsibilities expected of students as well as teachers were explained. The rest of the six days were used to teach the six lessons guided by the lesson plans prepared. Observation of students' activities during the lesson delivery was made in each lesson. The post-achievement test was then administered in day 7 of the study. There were also questionnaires for students of the experimental group to respond to and focus group discussions to get in-depth data on their experiences in learning through the activity-based approach.

Data Processing and Analysis

This study employed both descriptive and inferential statistics to analyse the data collected. The general achievement of students in the pre-and post-achievement tests were analysed with descriptive statistics such as means, standard deviations presented in tables, and paired sample t-test. Specifically, research questions one was analysed mainly using means, standard deviations and paired sample t-test. Also, research question two was analysed through descriptive statistics supported by focus group discussion, observation, and qualitative analysis of both the pre-and post-achievement tests results by outlining the various themes as they appear in students' presentations. Research question 3 on the other hand was analysed using both descriptive statistics and focus group discussions and observation. There were two research hypotheses that guided the study. Research hypothesis one was analysed using paired sample t-test to find out whether any differences existed between females and their male counterparts in their geometrical achievement and their perception on the activity-based approach of teaching and learning plane geometry. Also, research hypothesis two was analysed using Analysis of Covariance (ANCOVA). The equality of variance principle was also checked though the two participating schools in this study are in the same category by Ghana Education Service (GES) categorisation of schools and therefore, equal variances were already assumed. Also, since paired sample t-test and ANCOVA were used in the analysis of the data collected, normality was also checked using histogragh to ascertain whether the conclusions to be drawn from the results could be relied on. Reliability of the data on students' perception towards the activity-based approach of teaching and learning was tested on Chronbach's alpha (α) = 0.05. Fisher (2007) categorised the coefficient of reliability into less than 0.67 as poor, 0.67-0.80 as fair, 0.81-0.90 as good, 0.91-0.94 as very good, and finally, above 0.94 as excellent. In addition, an eta statistic squared was used to determine the magnitude of the difference (effect size) between mean scores of both the females and males in the post-achievement test. This was so because the difference might occur all by chance. According to McLeod (2019), the criterion for interpreting effect size is below 0.2 (trivial), = 0.2 (small) = 0.5 (medium) and = 0.8 (large). There was also a focus group discussion on improved understanding, remediation of misconceptions and students perception towards the activity-based approach in teaching and learning plane geometry.

Test of equality of variance

Equality of variance was checked for the pre-achievement test results between Experimental and Control groups to ascertain whether the condition of homogeneity of variances has not been violated. Therefore, the Levene's test of homogeneity of variance was conducted and presented in Table 2.

Table 2: Levene's Test of Equality of Variance

Pre-achievement Test	F	df	Sig.
Experimental Group	1.772	45	0.190
Control Group	2.058	35	0.160

Source: Field data (2022)

The table showed that equal variances have been assumed since the sig. values in both cases were greater than the alpha (α) = 0.05.

Normality of the post-achievement test

In a parametric analysis using test statistics such as t-test and ANCOVA, the continuous data must satisfy the condition of normality. To verify the normality assumption of the post-achievement test, the Shapiro-Wilk normality test was conducted and presented in Table 3.

Table 3: Shapiro-Wilk Normality test of Post-achievement Test

Achievement	Study	Shapiro-Wilk		
Test	Group	Statistic	df	Sig.
Post-achievement	Experimental	0.966	47	0.194
	Control	0.975	37	0.565

Source: Field data (2022)

Results of Table 3 showed that the post-achievement test of the two study groups was normally distributed since the sig. values recorded in both cases were all greater than the alpha value of 0.05. Following this, since the population in both study groups was large; the normality condition has not been violated. Therefore, results and conclusions from the data collected from both the experimental and control groups could be relied on. The normality of the data set was then graphically checked using histogragh to ascertain the veracity of this conclusion. These are presented in Figures 12 and 13.

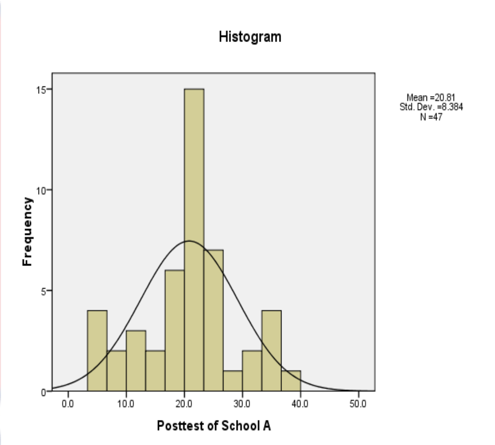


Figure 10: Normality histogragh of Experimental Group

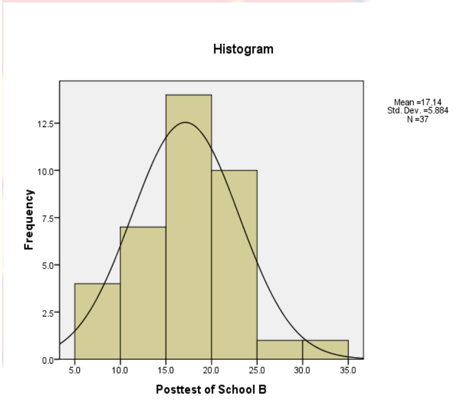


Figure 11: Normality histogragh of Control Group

The histograghs presented on the post-achievement test of both the experimental and control groups confirmed normality of the data set.

Chapter Summary

This chapter explained how the research was conducted. It discussed into details the research methods used in the study. The study employed a mixed methods design specifically the concurrent embedded design. Purposive sampling was used in selecting category A schools where as the two participating intact classes were selected through simple random sampling. Teacher made achievement tests, questionnaire, observation and focus group discussions were the main instruments used for data collection. Chronbach's alpha, means and standard deviations, frequencies and ANCOVA were used to analyse the quantitative data whiles the qualitative data were analysed through qualitative and thematic analyses of the pre-/post-achievement tests.

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

The purpose of the study was to investigate the effectiveness of the Activity-Based Approach (ABA) of teaching and learning on students' achievement in plane geometry. The study therefore, employed both quantitative and qualitative data to measure the effect of the Activity-Based Approach (ABA) of teaching and learning plane geometry on students' achievement and perception in two Category (A) schools in the Upper West region of Ghana. The concurrent embedded design employed in the study necessitated the collection of data using pre-and post-achievement tests, questionnaires, observation and focus group discussion guide (FGDG). Data was analysed using frequencies, paired samples t-test, ANCOVA, qualitative and thematic analysis. A total of 84 (27 girls and 57 boys) participants took part in the study. The results of the study were presented first on research question one and its related research hypotheses and then followed by research questions two and three respectively.

Demographic Information of the Study Participants

The total number of SHS2 students from the two selected category A schools representing the sample of the study was 84. Table 4 indicates the distribution of the sample by gender and the study schools students belong.

Table 4: Demographic Information of the Study Participants

			Experimental Group	Control Group	Total
Sex	Female	N	27	0	27
		%	32.1	0	32.1
	Male	N	20	37	57
		%	23.9	44.0	67.9
Total		N	47	37	84
		%	56.0	44.0	100

Source: Field data (2022)

Table 4 illustrates demographic characteristics of the study participants. It is observed from the table that out of the 84 students, 56% came from the experimental group and 44% from the control group. Also, the female students who participated in the study constituted 32.1% and that of the male population was 67.9%. Females were 27 in the experimental school out of the 44 students and 0 in control school out of the 37 students.

Results of the Study

In the subsequent sections, the results of the study which helped to answer the research questions as well as the research hypotheses which determine the effect of the two methods of teaching (Activity-Based Approach and Traditional Method) on students' achievement in plane geometry have been presented. This presentation was done first on research question one and followed by its related research hypotheses. Research questions two and three were respectively presented and analysed afterwards.

Research Question One (RQ1): To what extent do the activity-based approach and the traditional method of teaching and learning plane geometry affect students' achievement?

Research question one aimed to compare the pre-and post-achievement test results of students in the experimental group and their counterparts in the control group and to determine which of the two methods: Activity-Based

Approach (ABA) and the Traditional Method (TM) method was more effective in influencing students' achievement in learning plane geometry. Data on the research question were gathered through pre-and post-achievement tests. This research question was answered using descriptive statistics and paired samples t-test. The paired sample t-test conducted was to determine the effect of each teaching method on students' achievement in learning plane geometry. The results of the paired sample t-test between the pre-and post-achievement tests of the experimental group and that of the control group are presented in Table 5.

Table 5: Paired Sample T-test of Experimental and Control Groups

	Pre-test		Post-test		t	df	Sig.	Effect size
	M	SD	M	SD				
Experimental Group	5.638	3.046	21.156	8.384	-13.102	46	.000	0.80
Control group	6.135	3.326	17.135	5.884	-9.854	36	.000	0.73

Source: Field data (2022)

Table 5 shows the means and standard deviations of the pre-/post-achievement tests results of the two participating schools: experimental group (School A) and the control group (School B). The descriptive statistics and the paired samples t-tests which reveal the effect of the Activity-Based Approach (ABA) and the Traditional Method (TM) of teaching and learning plane geometry are discussed in the subsequent sections.

With regard to the effect of the Activity-Based Approach of teaching and learning plane geometry on achievement of students of the experimental group, the results as contained in Table 5 showed a numerical improvement in the achievements when the pre-and post-achievement tests scores of students were compared. The mean (21.156) and standard deviation (8.384) were recorded in the post-achievement test. In the pre-achievement test, a mean (5.638) and standard deviation (3.046) were recorded. With a mean difference of 15.518 between the post-achievement test and the pre-achievement test results, the data is suggestive of the fact that students' achievement has numerically improved in the post-achievement test. The paired sample t-test results between the pre-and post-achievement tests as presented in Table 5 revealed also a significant mean score difference; $t (46) = -13.102$, p-value $(0.000) < 0.05$. The impact of the activity-based teaching approach revealed a statistic of 0.80 which is indicative of a large effect size between the pre-and post-achievement tests mean scores (McLeod, 2019). This meant that the degree of the mean score difference between the post-and pre-achievement tests result of the students of the experimental group was large. The significant difference level in the improvement of students' geometric achievement is suggested to be as a result of supporting them to learn through the activity-based approach.

Also, the effect of the activity-based approach (ABA) on students' achievement in plane geometry based on gender was assessed. The purpose for measuring the achievement of students in the experimental group based on gender was to determine which group of students: male and female was more impacted by the activity-based approach of teaching and learning. Data was therefore, gathered through pre-and post-achievement tests and analysed through descriptive statistics such as means and standard deviations. The results of the descriptive statistics between the pre-and post-achievement tests of the experimental group based on gender are presented in Table 6.

Table 6: Descriptive statistics of students' achievement in the experimental group based on gender

Gender	Pre-Achievement Test		Post-Achievement Test		Mean Difference
	Mean	SD	Mean	SD	
Male	7.050	3.203	22.950	10.159	15.900
Female	4.593	2.500	19.222	6.542	14.629

Source: Field data (2022)

The descriptive statistics of students' in both the pre-and post-achievement test scores between females and their male counterparts showed that the two groups had numerical improvements in achievement in the post-achievement test over the pre-achievement test. In the pre-achievement test, the male students recorded a mean of 7.050 (SD = 3.203) and that of their female counterparts recorded a mean of 4.593 (SD = 2.500). Also, the male students recorded an average score of 22.950 (SD = 10.159) in the post-achievement test and their female counterparts recorded a mean of 19.222 (SD = 6.542). With a mean difference of 15.900 between the pre-and post-achievement tests of male students, the data is suggestive of the fact that they are having higher numerical improvements in achievement influenced by the activity-based approach of teaching and learning more than their female counterparts who recorded a mean difference of 14.629.

Again, students of the control group were also taught through the traditional method of teaching and learning plane geometry. Results as displayed in Table 5 showed numerical improvements in the achievements when the pre-and post-achievement tests scores of students of the control group were compared. The mean (17.135) and standard deviation (5.884) were recorded in the post-achievement test. In the pre-achievement test, a mean (6.135) and standard deviation (3.326) were recorded. With a mean difference of 11.00 between the post-achievement test and the pre-achievement test results, the data is suggestive of the fact that students' achievement has numerically improved in the post-achievement test. The paired sample t-test results between the pre-and post-achievement tests as presented in Table 5 revealed also a significant mean score difference; t (36) = -9.854, p-value (0.000) $<$ 0.05. The impact of the traditional method of teaching revealed a statistic of 0.73 which is indicative of a moderate effect size between the pre- and post-achievement tests mean scores (McLeod, 2019). This meant that the size of the mean score difference between the post-and pre-achievement tests result of the students of the control group was moderate. The significant difference level in the improvement of students' geometric achievement in the post-achievement test is suggested to be as a result of introducing new perspective into the traditional method of teaching and learning plane geometry. Students were allowed to ask and answer questions on concepts and theorems they did not understand after every teaching and learning session. This practice deviated a little from the traditional conventional method where the next significant activity after teaching is exercises.

Generally, each of the methods (activity-based approach and the traditional method) of teaching and learning plane geometry had a significant impact on the achievements of the students in the group. The students experienced various levels of improvements in their understanding and achievements of concepts and theorems of plane geometry. The paired samples statistics revealed large and moderate effect sizes on students' achievements from their pre-and post-achievement test scores in the two groups: experimental and control respectively. The two teaching methods revealed different effect sizes of 0.80 and 0.73 on students' achievements for the activity-based approach and the conventional method respectively. A cursory look at the effect of each method of teaching indicates there were improvements in each teaching method on students' achievements and understanding. With an effect size of 0.80, the activity-based approach of teaching and learning plane geometry had a greater impact on students' achievement than their counterparts who were taught with the traditional method that recorded an effect size of 0.73. Also, the male students of the experimental group were impacted largely in their achievement by the activity-based approach of teaching and learning plane geometry than their female counterparts with an effect size of 0.84.

In further comparing the achievement of students of the experimental group taught through activity-based approach of teaching and learning plane geometry and their counterparts taught with the traditional method, two research hypotheses were employed for the comparative analysis of students' achievement in the two study groups.

H_0 1: There is no statistically significant difference between the post-achievement test mean scores of females and their male counterparts of students taught lessons with Activity-Based Approach (ABA) of teaching and learning plane geometry.

This research hypothesis was purported to indicate whether there was a statistically significant difference in the mean scores of the post-achievement test between females and their male counterparts of the experimental group taught through the activity-based approach of teaching and learning plane geometry. In testing this hypothesis, the paired samples t-test was used to determine whether the activity-based approach (ABA) differs in its effect towards students' achievement in learning plane geometry based on gender. Therefore, the paired samples t-test was conducted at 5% level of significance to compare the post-achievement test mean scores between females and their male counterparts of the experimental group and presented in table 7.

Table 7: Paired samples t-test of students' achievement by gender

Mean	SD	t	df	Sig.(2-tailed)	Effect size
-19.2340	8.5089	-15.497	46	.000	0.84

Source: Field data (2022)

The paired samples t-test of the students' post-achievement test scores between females and their male counterparts showed that the difference between their overall achievements is statistically significant, t(46) = -15.497, sig. value = 0.000 which is less than the alpha (α) value of 0.05. The difference in achievement between females and their male counterparts of the experimental group revealed a statistic of 0.84 which is indicative of a large effect size between the pre-and post-achievement tests mean scores (McLeod, 2019). This meant that the degree of the mean score difference between the post-and pre-achievement tests result of the students of the experimental group was not by chance. The null hypothesis was therefore rejected and concluded that there were statistically significant differences that existed between students of the experimental group based on gender in their post-achievement test results. Therefore, the achievement difference in the post-achievement test scores between females and their male counterparts was statistically significant towards using the activity-based approach of teaching and learning plane geometry.

Content analysis of the post-achievement test results of both females and their male counterparts taught through the activity-based approach further showed that the male students had better improvements in their geometric achievement than their female counterparts. Critical observation of students' post-achievement test scripts revealed that the appropriate theorems and principles could not be identified and applied by the female students in answering a significant number of the questions, but on the contrary, a majority of students of the male category applied appropriately the theorems and principles needed to answer the post-achievement test.

H_0 2: There is no statistically significant difference between the post-achievement test mean score of students taught lessons with Activity-Based Approach (ABA) and their counterparts taught through the Traditional Method (TM) of teaching and learning plane geometry.

This research hypothesis was purported to indicate whether there was a statistically significant difference in the mean scores of the post-achievement test between the students taught with the activity-based approach and their counterparts taught through the traditional method. Activity-based approach of teaching and learning was used in the experimental group and the traditional method was used in the control group. In testing this hypothesis, the analysis of covariance (ANCOVA) was used to determine whether the two teaching approaches were different in their effect towards students' achievement in learning plane geometry. The results of the analysis of covariance (ANCOVA) are shown in Table 8.

Table 8: ANCOVA of Experimental and Control Groups

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Pre-test	1783.059	1	1783.059	21.493	.000	.389
Group	2196.013	1	2196.013	60.242	.000	.639
Error	2030.020	34	59.707			
Corrected	2179.000					
Total		36				

R Squared = .094 (Adjusted R Squared = .040)

Source: Field data (2022)

The comparative analysis of the post-achievement test scores of students of both the experimental and control groups after the intervention showed that the effect of the activity-based approach of teaching and learning plane geometry on the experimental students' achievement is differently statistically significant from students of the control group taught through the traditional method, [$F(1, 34) = 60.242$; p-value $(0.000) < 0.05$]. The null hypothesis was therefore rejected and concluded that there were statistically significant differences that existed between students of the experimental group and their counterparts of the control group in their post-achievement test results. This indicated that students of the experimental group had higher achievements than their counterparts of the control group in the post-achievement test. The effect size of 0.639 realized was caused by the activity-based approach on students' achievement in the post-achievement test. This showed that 63.9% of the improvements realized in the post-achievement test by students of the experimental group resulted from the activity-based approach used in the group.

The moderately large effect size of the activity-based approach of teaching and learning on the achievement of students was noted also in the pre-and post-achievement tests scores within-group analyses of the experimental and control groups. From Table 5, the activity-based approach explained 80.0% (effect size = 0.80) improvements in the post-achievement test against 73.0% (effect size = 0.73) in the post-achievement test scores explained by the traditional method of teaching on the control group.

Significant achievement disparities have also been identified between students taught through the activity-based approach and their counterparts taught through the traditional method based on the content analyses of the post-achievement test scripts of some specific students. Critical observation of students' post-achievement test scripts revealed that the appropriate theorems and principles could not be identified and applied by the students of the control group in answering question 5 (a) ii as indicated in figure 12. But, on the contrary, a significant number of students of the experimental group applied appropriately the theorems and principles needed to answer the said question. Question 5 (a) ii is illustrated as follows.

In the diagram, O is the centre of the circle, |PS| is a tangent to the circle at the point T and |SQ| is a straight line. Angle ROT is 100º. Find the value of < QST.

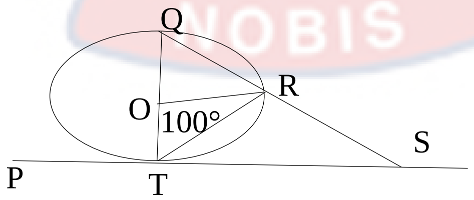
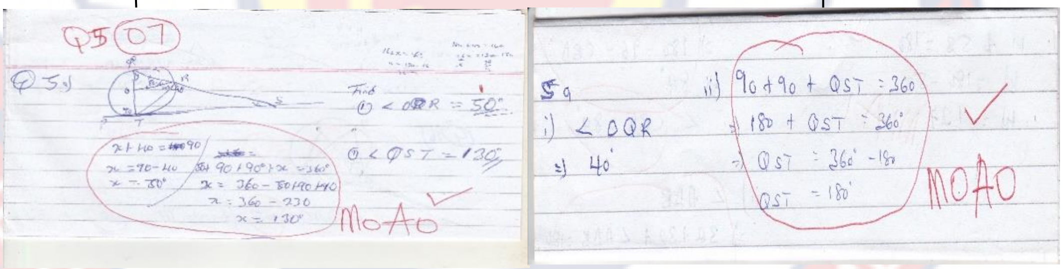


Figure 12: Post-Achievement Test question 5 (a) ii

Post-achievement test question 5 (a) ii required the identification and usage of at least three theorems as follows: Angle TQS = $\frac{1}{2}$ of < TOR = 50° (relationship between angle at the centre and one at the circumference formed by the same chord). Angle QTS = 90° (angle created by the radius of a circle and a tangent at the point of contact equals 90°). Interior angles of a triangle sum up to 180°, implies, < QST + <QTS + < TQS = 180°. Therefore, < QST + 90° + 50° = 180°, <QST = 180°- 140° = 40°.

In the experimental group, 83% (39 out of 47) identified and applied these theorems appropriately to solve the question. On the other hand, 70% (26 out of 37) of students of the control group failed to identify and apply the theorems to answer correctly the given question. Excerpts of students' responses to question 5 (a) ii of both the experimental and control groups in the post-achievement test are compared in figure 13.

Answer sheet samples of control group



Answer sheet samples of experimental group

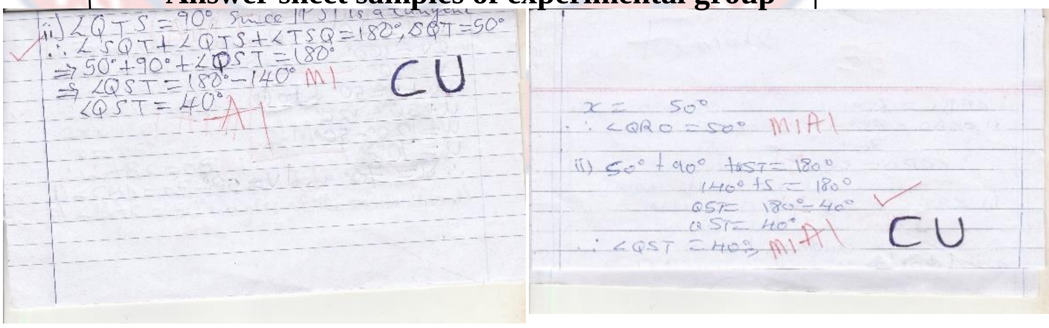


Figure 13: Excerpts of answer sheets of experimental and control groups

From figure 13, it is realised that students of the control group showed no conceptual understanding in answering question 5 (a) ii but on the contrary their counterparts of the experimental group had shown substantial level of conceptual understanding of the necessary concepts and theorems needed to answer the said question. These excerpts therefore, draw attention to how the activity-based approach as compared to the traditional method could help explain the significant achievement differences realised between the two study groups.

Relying on the post-achievement test results, it showed evidence that both the activity-based approach and the traditional method of teaching and learning plane geometry had significant positive effects on students' achievements. However, students taught through the activity-based approach had the capacity to learn and improve achievement than their counterparts taught through the traditional method. Thus, though the two teaching methods both impact learning, the activity-based approach does have a greater positive effect on students' learning experiences and improvements in plane geometry.

Research Question Two (RQ2): How can the improvements in teaching using the activity-based teaching approach and enhanced conceptual understanding of concepts on plane geometry be explained and understood?

Research question 2 aimed to explore how improvements in students' achievement in plane geometry is influenced by enhanced conceptual understanding of concepts gained through the activity-based approach of teaching and learning. Data on the research question were gathered through pre-and post-achievement tests, focus group discussion and observation of students' classroom practices on teaching and learning of plane geometry. These practices included whole class discussions and students' presentations on the marker board. The analysis was then carried out through qualitative examination of the pre-and post-achievement tests of the experimental group, focus group discussions and observations of students' discussions and responses in the whole class deliberations and presentations. Concepts of plane geometry as a broad area of study were categorised in this research work into four domains: concept of triangle, concept of quadrilateral, chord theorems, and tangent theorems.

Concept of triangle took into consideration the issue of isosceles triangle, equilateral triangle, and sum of interior angles of a triangle as well as the concept that an exterior angle of a triangle is equal to the sum of its two opposite interior angles. Sum of interior angles of a quadrilateral, cyclic quadrilateral, opposite angles of a cyclic quadrilateral were considered under the broad concept of the quadrilateral. Also, angles made by the diameter at the circumference of circle, a chord making two or more angles in the same segment, and an angle made at the centre and one at the circumference of the circle by the same chord were the concepts considered under the chord theorems. Lastly, under tangent theorems, this study considered the issue of a radius of a circle meeting a tangent at the circumference, two or more tangents produced from an external source, and the issue of an angle created by a chord at the point of contact with a tangent equals the angle at the alternate segment.

Qualitative analysis of both the pre-and post-achievement tests was done with the mind of identifying students' conceptual understanding (CU) of plane geometric concepts, no conceptual understanding (NCU), and number of students who did not answer the questions (NA) on a particular concept. To get descriptive statistics on students' level of conceptual understanding (CU) of the concepts of plane geometry in both the pre-and post-achievement tests and number of students who did not respond to certain questions (NA) purported to measure the conceptual understanding of concepts of plane geometry, frequency counts were made under the various sub-concepts of plane geometry and tabulated as presented in Table 9.

Table 9: Descriptive statistics of the levels of students' conceptual understanding in both pre-and post-achievement tests

Concepts of Plane Geometry	Pre-Achievement Test			Total	Post-Achievement Test			Total
	CU	NCU	NA		CU	NCU	NA	
Concept of Triangle	8	28	11	47	24	11	12	47
Concept of Quadrilateral	10	29	08	47	31	08	08	47
Chord Theorems	5	30	12	47	25	12	10	47
Tangent Theorems	7	22	18	47	32	06	09	47

Source: Field data (2022)

Table 9 shows the level of students' conceptual understanding (CU) of concepts of plane geometry and number of students who could not answer the questions (NA) in both the pre-and post-achievement tests. It was observed that in the pre-achievement test, chord theorems recorded the highest number of 30 students who had no conceptual understanding and tangent theorems recorded the least number of 22 students who had no conceptual understanding. Again, 10 students had the highest number of conceptual understanding in the area of concept of quadrilateral and the least number of five was recorded under chord theorems in the pre-achievement test. Also, 18 students did not answer questions under the tangent theorems in the pre-achievement test and the least number of 8 students did not answer questions under the concept of quadrilateral.

In the post-achievement test, tangent theorems recorded the highest number of 32 students who had conceptual understanding and the least number of 24 students was recorded under the concept of triangle. Chord theorems recorded the highest number of 12 students who had no conceptual understanding and the least of 6 was recorded under tangent theorems. The number of students who could not answer the questions under the concept of triangle was 12 and the least number of 8 students could not answer the questions under the concept of quadrilateral in the post-achievement test.

Qualitative analysis of both the pre-and post-achievement tests was also done to identify students' misconceptions (Mc) of plane geometric concepts, no misconceptions (NMc), remediation of misconceptions (RMc) and number of students who did not answer questions (NA) on a particular concept purported to measure a misconception. Descriptive statistics on students' level of misconceptions of the concepts of plane geometry in both the pre-and post-achievement tests and the number of students who did not respond to certain questions purported to measure the misconceptions of students on concepts of plane geometry, are presented in table 10.

Table 10: Descriptive statistics of the levels of students' misconceptions in both pre-and post-achievement tests

Themes	Pre-achievement Test				Total	Post-achievement Test				Total
	Mc	NMc	RMc	NA		Mc	NMc	RMc	NA	
Concept of triangle	28	8	0	11	47	11	07	17	12	47
Concept of quadrilateral	29	10	0	08	47	08	10	21	08	47
Chord theorems	30	5	0	12	47	12	05	20	10	47
Tangent theorems	22	7	0	18	47	06	07	25	09	47

Source: Field data (2022)

Table 10 shows the level of students' misconceptions (Mc) of concepts of plane geometry and the number of students who could not answer the questions (NA) in both the pre-and post-achievement tests. In this study, no misconceptions (NMc) means that the said student had the concepts correct in the pre-achievement test without the intervention and subsequently got it right after the intervention. If a student got a particular concept wrong because of a misconception in the pre-achievement test and subsequently got it right after the intervention, then this is kept under remediation of misconceptions (RMc). No answer (NA) means that the student did not answer the question that is purported to identify or remediate a particular misconception.

It is observed from Table 10 that in the pre-achievement test, chord theorems recorded the highest number of 30 students who had misconceptions and tangent theorems recorded the least number of 22 students who had misconceptions in the concept. Again, 10 students representing the highest number had no misconceptions in the pre-achievement test under concept of quadrilateral and the least number of five was recorded under the concept of chord theorems in the pre-achievement test. Also, 18 students did not answer questions under the tangent theorems in the pre-achievement test and the least number of 8 students did not answer questions under the concept of quadrilateral. The data presented painted a picture that appears to suggest that the concept of quadrilateral seemed easy to students in the pre-achievement test that was why many students attempted questions on this concept. The data further revealed that the highest number of misconceptions was recorded under chord theorems. There was no remediation of misconceptions at the level of the pre-achievement test and so the column recorded 0 for every student.

However, in the post-achievement test, tangent theorems recorded the highest number of 25 students who had remediated their misconceptions and the least number of 17 students remediated their misconceptions under the concept of triangle. Chord theorems again recorded the highest number of 12 students who had misconceptions in the post-achievement test and the least of 06 was recorded under tangent theorems. Also, the highest number of ten students had no misconception under concept of quadrilateral in the post-achievement test and only 5 students had no misconceptions under chord theorems. The number of students who could not answer the questions under concept of triangle was 12 and the least number of 8 students did not answer the questions under the concept of quadrilateral in the post-achievement test. The data therefore, appears to suggest that many students were afraid of questions on the concept of triangle a reason 12 of them failed to answer questions on this concept and that, questions on the concept of quadrilateral were relatively easy to handle.

To support the quantitative data, focus group discussion (FGD) was carried out to obtain students thoughts on the concepts of plane geometry. The FGD necessitated that students respond to the question: "Which theorems of plane geometry can you say you understood better after the teaching?"

Student A: *I understood that opposite angles of a cyclic quadrilateral are supplementary, sum of interior angles of a triangle add up to 180°, and also that angles on a straight line sum up to 180°. But I did not understand chord theorems and same to my colleagues.*

Student B: *I can work the questions but cannot explain using the various theorems and properties. I did not understand the concept of opposite angles of a cyclic quadrilateral.*

Students C: *I understood that opposite angles of a cyclic quadrilateral add up to* 180°. *I also know that an exterior angle of a triangle is equal to the sum of its two interior angles.* [There was a misconception identified here in that an exterior angle of a triangle equals the sum of its two opposite interior angles and not just two interior angles]. *But, I have problems with the identification of cyclic quadrilateral and cannot also differentiate between a tangent and a segment.*

Students D: *I understood that supplementary angles add up to 180°, sum of angles on a straight line is 180°, and angles at a point add up to 360°. I also know that two tangents drawn from an external point to a circle are equal but I did not understand the other tangent theorems.*

The results from the focus group discussions revealed two main areas of plane geometry where students showed little conceptual understanding. These were areas of cyclic quadrilateral and chord theorems. With the exception of cyclic quadrilateral, chord theorems have again been identified as a problem area to students confirming the qualitative analysis results of the pre-and post-achievement tests. The focus group discussion showed that students had enhanced conceptual understanding of the concepts of plane geometry as they were able to itemise and explain some of the theorems and principles.

Activities of students during and after lesson presentation in both group and whole class discussions were as well observed with the mind of identifying their conceptual understanding of concepts of plane geometry in the six different lessons taught. Lesson one (L1) covered triangle and parallel lines, lesson two (L2) looked at quadrilaterals whereas lesson three (L3), lesson four (L4) and lesson five (L5) covered chord theorems respectively in the areas of a chord making angles in same and opposite segments, angles made by a chord at the centre of a circle and one at the circumference, and theorems around the diameter. Finally, lesson six (L6) considered theorems around the tangent of a circle. These observations are presented in Table 11.

Table 11: Observations on students' level of conceptual understanding in the six different lessons

Lesson (L)	No Conceptual Understanding (NCU)	Conceptual Understanding (CU)
L1	Students could not differentiate clearly between isosceles triangle and that of the equilateral triangle	Students understood the relationship between an exterior angle of a triangle and the sum of its opposite interior angles
L2	Though students could identify a kite, the angle properties of this plane figure was not well understood	Angle properties of a rhombus was well understood
L3	Students taught that any four sided figure in a circle must have the properties of a cyclic quadrilateral	Angle properties of a cyclic quadrilateral was understood

L4	Students did not understand that when a chord makes an angle at the centre of a circle the two radii must be equal and that the base angles of the triangle are equal	Students understood that half of the angle at the centre is equal to the angle at the circumferences if formed by the same chord
L5	No identification of students not having conceptual understanding on the concept of the diameter of a circle was made	Students understood that the diameter of a circle makes an angle of 90° at the circumference
L6	Students did not understand that angle a chord makes with a tangent is equal to the angle in the alternate segment	Students understood that the radius of a circle at the point of contact with the tangent equals 90°

Source: Field data (2022)

Analysis of the observational guides on the six different lessons revealed that chord theorems gave students a big challenge to grapple with. Many students did not understand especially the theorem that "angles formed by the same chord in the same segment are equal". Students could not therefore apply appropriately the chord theorems in answering the required questions. Areas of plane geometry that students understood relatively better were the concept of quadrilateral and tangent theorems from the observations of the researcher. These observations were supported by the results of the qualitative analysis of the post-achievement test where 31 students had enhanced conceptual understanding on the concept of quadrilateral and 32 students on tangent theorems.

Thus, the qualitative analysis of both the pre-and post-achievement tests, focus group discussion and the observation of students' classroom activities all point to the fact that chord theorems are major areas students had problems with and also that enhanced conceptual understanding of concepts of plane geometry affect positively remediation of misconceptions and students' achievement.

Research Question 3: What perceptions do students hold about the activity-based approach of teaching and learning plane geometry?

Students' perception towards the Activity-Based Approach (ABA) of teaching and learning plane geometry was assessed for the experimental group, using students' perception questionnaires, focus group discussion and observational guides. The perception of students towards the Activity-Based Approach (ABA) was judged using a five-point Likert scale, ranging from strongly disagree-1 to strongly agree-5. Strongly agree and agree means positive disposition whereas strongly disagree and disagree both means negative perception. A mean score of above 3.0 means positive perception and that of below 3.0 means a negative perception. However, a mean score of 3.0 simply means neutral (not showing positive or negative perception). The students' perception questionnaire was developed on four sub-scales to include interest of students towards the Activity-Based Approach (ABA) in learning plane geometry, comprehension, content delivery, and usage. There were 18 items on the perception questionnaire for students to respond to. Four of these items fell under interest, seven of the items fell under comprehension, and five items fell under usage. The least value of two items fell under content delivery. Four volunteers took part in the focus group discussion and the whole class was also observed with the mind of determining students overall perception towards the Activity-Based Approach (ABA) of teaching and learning plane geometry under the four sub-scales. The reliability coefficient of the overall instrument on students' perception was calculated on alpha value of 0.05. It was found to be 0.86. Reliability value of 0.86 is said to be good (Fisher, 2007). Table 12 shows the summary results of the students' perception questionnaire towards ABA in teaching and learning plane geometry on the four sub-scales; interest, comprehension, content delivery, and usage.

Table 12: Students' perception towards the Activity-Based Approach (ABA)

	Interest	Comprehension	Delivery	Usage
N	47	47	47	47
Mean	4.4788	4.4802	4.5319	4.7021
Std. Deviation	0.4941	0.4228	0.4265	1.9271

Source: Field data (2022)

Results from Table 12 suggest that students taught through the Activity-Based Approach (ABA) had positive feedback on this method of teaching. The reported mean score on the sub-scale 'Interest' was (M = 4.4788, SD = 0.4941) indicating that students showed interest in learning through the activity-based approach. Also, the mean score on 'comprehension' was reported as (M= 4. 4802, SD = 0.4228) which showed that students have agreed that the activity-based approach of teaching and learning helped them to understand the concepts of plane geometry. Again, the mean score on 'content delivery' was reported to be (M = 4.5319, SD = 0.4265) indicating that the arrangement and delivery of the contents of the lessons was systematic, appropriate and clear. Using the activity-based approach in teaching and learning plane geometry and other topics of mathematics was categorised under the sub-scale 'Usage'. This sub-scale reported a mean score of (M = 4.7021, SD = 1.9271) indicating a positive perception of students towards the activity-based approach in the area of its usage. With a mean value of above 4.0 for each sub-scale, the perception of students towards the activity-based approach is positive.

Similarly, students' responses to the focus group discussion further revealed their perception towards the activity-based approach of teaching and learning plane geometry. To assess the perception of students towards the activity-based approach of teaching and learning plane geometry, the focus group discussion necessitated that students respond to the question ''what is your general view on the activity-based approach of teaching and learning plane geometry?'' Some of the quoted responses from the focus group discussion have been related to the students.

Student A:

The method is interesting, it helped us to understand plane geometry well, it should be applied to all topics in mathematics and teaching through this method was good.

Student B:

It encouraged me to interact with my colleagues. It is a good method and it helped me to learn plane geometry better.

Students C:

The approach is very interesting when you know the laws. The method helps us to understand plane geometry better. It helped us to share ideas. It should be used in teaching.

Student D:

This method of teaching is very interesting. It helped me to understand plane geometry better.

The results from the focus group discussion revealed that students' perception towards the activity-based approach is not different from the results of the students' perception questionnaire. Students in general showed a positive perception towards this approach. They see this method to be interesting, helps in understanding and that it should be used in teaching plane geometry in particular and mathematics in general. Also, students postulated that teaching through the activity-based approach is the way to go. It was also observed from the teaching and learning process that students were interested in learning with this approach. This was so when one student could not hide her joy than to say—*today I did not sleep in mathematics class.*

Also, the observation of group and whole class discussions and activities of students further revealed their perception towards the activity-based approach of teaching and learning. Students actively took part in the class activities and defended their answers during the whole class discussions showing understanding of the concepts of plane geometry. They were therefore, excited and wished always that the mathematics lessons should not come to an end. Students in general showed positive perception towards this method of teaching and learning as observed by the researcher. Therefore, analysis of the students' perception questionnaire, the focus group discussion and the observation of the classroom activities of learners all point to the same direction that students' disposition towards the activity-based approach of teaching and learning is positive.

Similarly, the perception of students towards the activity-based approach of teaching and learning between females and their male counterparts of the experimental group was assessed. The purpose of this assessment was to determine whether there existed any differences in perception towards the activity-based approach of teaching and learning plane geometry based on gender and whether those differences could be relied on.

Therefore, paired samples T-test were conducted at a 5% level of significance to compare the perception of students towards the activity-based approach (ABA) based on gender in all the four sub-scales of the perception instrument. The paired samples T-test were conducted and reported in Table 13.

Table 13: Paired samples t-test of students' perception on the activity-based approach

Sub-scale	Mean	SD	t	df	Sig. value	Effect size
Interest	-16.34	2.01	-55.628	46	.000	0.98
Comprehension	-2.97	2.96	-68.919	46	.000	0.99
Content Delivery	-1.20	1.39	-39.256	46	.000	0.97
Usage	-1.72	2.34	-15.132	46	.000	0.83

Source: Field data (2022)

The paired samples t-test of the students' perception towards the activity-based approach of teaching and learning based on gender on the four sub-scales of the perception instrument showed that the differences between 78females and their male counterparts were statistically significant with a reported sig. value of 0.000 for all four sub-scales and the least effect size value of 0.83 which is large. This shows that the overall perception difference of students towards the activity-based approach of teaching and learning plane geometry between females and their male counterparts was statistically significant. Assessing the difference in perception of both females and their male counterparts has revealed significant differences existed between them. The male students showed more positive perception towards the activity-based approach of teaching and learning plane geometry than their female counterparts. Notwithstanding the difference in perception between females and their male counterparts towards the activity-based approach of teaching and learning plane geometry, both sexes had a positive perception towards this method of teaching and learning.

Discussion of Results

In this section of the research study, the findings are discussed. The findings suggest that both the activity-based approach and the traditional method of teaching and learning plane geometry had positive effects on students' achievement in the post-achievement test. There was however, a statistically significant difference between the post-achievement test scores of the experimental group and the control group. Also, achievement of females and their male counterparts of the experimental group further revealed that there was a statistically significant difference in the post-achievement tests results based on gender. Students of the experimental group had positive perceptions towards the activity-based approach of teaching and learning plane geometry. The discussion would be based on both the research questions and research hypotheses.

Effect of the Activity-Based Approach and the Traditional Method of Teaching and Learning Plane Geometry on Students' Post-Achievement Test Scores

Results of the pre-achievement test as shown in Table 5 revealed that out of 40 marks the experimental group had a mean score of 5.638. But in the post-achievement test the mean score was 21.156. With a mean difference of 15.518, students' achievement in plane geometry has improved significantly in the post-achievement test. This means that the activity-based approach has a positive effect on students' achievement. Also, comparing the achievement of students in the post-achievement test based on gender, the results as presented in table 7 indicated that the paired samples t-test of the students post-achievement test scores between females and their male counterparts showed the difference between their overall achievement was statistically significant, t(46) = -15.497 and a sig. value of 0.000. The effect size of 0.84 was then calculated to find out the difference in magnitude between the females and their male counterparts in their post-achievement test scores. With effect size of 0.84 which is large (McLeod, 2029), the difference in achievement was considered statistically significant. From the content analysis of the post-achievement test scores, the male student has overshadowed the female counterpart in the experimental group. The difference in achievement between females and their male counterparts may be as a result of lack of self-confidence on the part of the female students and not because they are weak. This claim was supported by Uwineza, Rubagiza, Hakizimana and Uwamahoro (2018) who concluded from a study that, most females have low self-esteem to the study of mathematics and that females in general feel shy to ask questions in class whether they understand the concept or not. This was evident when a female student in the control group said 'sir, you know mathematics is not for us' in response to a question why the girls are always dull in the mathematics class?

The outcome of this study putting the male students ahead of their female counterparts in their mathematics achievement has contradicted the findings of Brown and Kanyongo (2010). In their study conducted in Trinidad and Tobago to find out the differences in mathematics achievement by gender, it was revealed that females had higher mean scores than boys which suggested that higher mathematics achievement was in favour of girls. Again, a study conducted to find out the differences in achievement by gender in Ghana National College, it was found that no such differences existed in the experimental group (Arhin & Coffoe, 2015). Also, a study conducted in the specific domain of geometry in mathematics, it was found that females outperformed their male counterparts (Fabiyi, 2017) which did not support the current study. The current study agreed with the work of Nganga, Mureithi and Wambugu (2018). In their study, they came to the conclusion that female learners are nowhere nearer to their male counterparts when it comes to achievement in mathematics. Though male students outperformed their female counterparts in this study, there were general achievement improvements recorded by both sexes in the post achievement test over the pre-achievement test.

The improvements in students' geometric achievement in the post-achievement test may be due to the manner in which the activity-based approach was carried out in this study that led to the development of positive perceptions towards this approach of teaching and learning, enhanced conceptual understanding and remediation of misconceptions of concepts of plane geometry. In using the activity-based approach, students were grouped in pairs, they measured angles, discuss their findings with the whole class in relation to the theorems identified, and applied those theorems in solving related problems. Students in pairs then presented their solutions for whole class discussions helping them to develop conceptual understanding and to remediate any misconceptions. The improvements in students' achievement in the post-achievement test have therefore supported several research findings in the use of the activity-based approach in teaching and learning. Several research studies conducted alluded to the fact that the activity-based approach helped students to identify and remediate misconceptions, develop conceptual understanding and improved their overall achievement (Ilyas & Saeed, 2018; Pokhrel, 2018; Noreen & Rana, 2019; Unal, 2019). The implication is that if the activity-based approach of teaching and learning is properly carried out, it will help students to enhance their conceptual understanding, remediate misconceptions, and develop positive perceptions in learners towards the study of plane geometry in particular and mathematics in general which will subsequently improve students achievement.

Also, in the pre-achievement test, the control group had a mean value of 6.135. But, in the post-achievement test, the mean value was 17.135. With a mean difference of 11.0, the control group has improved significantly in the post-achievement test. This means that if the traditional method is properly carried out, it is not as bad as how people see it to be. This finding contradicts that of Salifu (2020) that the traditional method of teaching and learning leads to poor achievements in mathematics.

Generally, the post-achievement test results of both the experimental and control groups have improved significantly over the results of the pre-achievement test. Though there was an improvement in the post-achievement test scores, content analysis of the general results revealed that only 30 out of 47 students of the experimental group had a score of 20 and above. This is made up of seventeen (17) girls and thirteen (13) boys. This indicates that the percentage pass was 64%. Also, in the control group, twelve (12) out of 37 students attained a pass mark of 20 and above in the post-achievement test. It therefore, means that the percentage pass for the control group in the post-achievement test was 32%. The percentage passes of the two study groups have revealed that students of the experimental group performed relatively better than their counterparts of the control group. However, content analysis of the post-achievement tests of the two study groups has revealed that students in general are weak in the area of plane geometry confirming the findings of other researchers (Fabiyi, 2011; Sah, 2016; Adolphus, 2011).

Comparison of the Activity-Based Approach and the Traditional Method on Students Achievement

One research hypothesis was formulated to compare the achievements in the post-achievement test of students in the two study groups. The objective was to determine the effectiveness of the activity-based approach of teaching and learning plane geometry whilst setting the traditional method of teaching and learning as a yardstick for this measure.

Comparing the post-achievement test results of the two study groups, the mean difference between the experimental and control groups was 4.021. This mean difference indicates a relatively higher achievement in the post-achievement test by the experimental group over the control group. But this mean difference must be tested through a hypothesis to ascertain whether the difference in achievement between the two study groups was really statistically significant.

The comparative analysis of the post-achievement test scores of students taught through the activity-based approach and their counterparts taught through the traditional method using analysis of covariance (ANCOVA) showed statistically significant difference between the two approaches of teaching and learning [$F(1, 34) = 60.242$; $p < 0.05$]. The null hypothesis was therefore, rejected and concluded that there were statistically significant differences in the post-achievement test scores between the experimental and control groups. This indicates that students of the experimental group achieved more than their counterparts of the control group in the post-achievement test. This finding is in conformity with that of Adu-Gyamfi (2014) who found that the experimental group taught with the activity-based approach (ABA) actually outperformed their counterparts taught through the traditional method.

Effects of Enhanced Conceptual Understanding on Students' Achievement

One research question was formulated in this study to explain the improvements in students' achievements in the post-achievement test scores of the experimental group. The objective was to determine how enhanced conceptual understanding of concepts of plane geometry gained through the activity-based approach of teaching and learning could help explain the improvements in students' achievement in the post-achievement test.

Results as shown in Table 9 indicate that students' conceptual understanding of concepts of plane geometry has improved in the post-achievement test over the pre-achievement test. The results as indicated showed that the highest number of unanswered questions of 18 as recorded under tangent theorems in the pre-achievement test has reduced to 9 in the post-achievement test. Also, the highest number of 30 students recorded under chord theorems who had no conceptual understanding in the pre-achievement test has reduced to 12 in the post-achievement test. Again, the least number of 5 students who had conceptual understanding under the concept of chord theorems in the pre-achievement test has increased to 25 in the post-achievement test. This showed that the general students' conceptual understanding of concepts of plane geometry has increased in the post-achievement test, a reason many more questions were answered. This enhanced conceptual understanding of concepts of plane geometry was also revealed in the focus group discussion where students were able to explain theorems and principles of plane geometry they understood better. One of the students said 'I understood that the sum of the two opposite interior angles of a triangle equals the exterior angle'.

Again, results as shown in Table 10 indicate that students' enhanced conceptual understanding has had a positive effect on their identification and remediation of misconceptions on concepts of plane geometry in the post-achievement test over the pre-achievement test. The results as indicated showed that the highest number of 30 students recorded under chord theorems who had misconceptions in the pre-achievement test has reduced to 12 in the post-achievement test. Again, out of the 30 students who had misconceptions under the chord theorems in the pre-achievement test, 20 of them have remediated their misconceptions in the post-achievement test. This showed that majority of the students have identified and remediated their misconceptions on concepts of plane geometry in the post-achievement test. This enhanced conceptual understanding of the concepts of plane geometry may explain the reason for the improved achievement in the post-achievement test scores of students.

In this study, the activity-based approach as used in the teaching and learning of plane geometry to the experimental group has led to an enhanced conceptual understanding and enhanced remediation of misconceptions of concepts of plane geometry. This has led to an improved students' achievement in plane geometry. Several research studies have identified the activity-based approach of teaching and learning as a good medium for the development of conceptual understanding in students, remediation of misconceptions and subsequent improvement in students' mathematics achievement. In a study conducted by Ilyas and Saeed (2018), they alluded to the fact that the activity-based approach of teaching and learning created a better platform for students to identify and remediate misconceptions, develop deep conceptual understanding and subsequently improves students' mathematics achievement. Other research studies also concluded that the activity-based approach of teaching and learning develops in students positive attitudes towards the study of mathematics and improves achievement in the subject (Noreen & Rana, 2019; Unal, 2019).

Students' Perception towards the Activity-Based Approach of Teaching and Learning Plane Geometry

One research question was formulated in this study to determine the perception of students in the experimental group towards the activity-based approach of teaching and learning plane geometry. The objective of the research question was to critically examine and inform whether students have positive or negative perceptions towards this approach of teaching and learning.

The results shown in Table 12 suggest that students taught through the Activity-Based Approach (ABA) of teaching and learning plane geometry had positive feedback on this method of teaching and learning as the mean scores on all the four sub-scales were well above 3.0. The reported mean score on the sub-scale ‘Interest’ was (M = 4.4788, SD = 0.49), ‘Comprehension’ was reported as (M = 4. 4802, SD = 0.42), ‘Content Delivery’ was (M = 4.5319, SD = 0.43) and that of ‘Usage’ recorded a mean score of (M = 4.7021, SD = 1.93). The mean scores in all the sub-scales of the students’ perception questionnaire were above 3.0 which showed that students in general have positive perception towards the activity-based approach of teaching and learning plane geometry.

Similarly, the perception of students towards the activity-based approach of teaching and learning based on gender was also measured using paired sample t-test. The paired sample t-test results are shown in Table 13. With significance value of 0.000 on all sub-scales and the least effect size of 0.83 considered to be large (Fisher, 2007), the difference in perception between females and their male counterparts was considered statistically significant. Though both females and their male counterparts showed a positive perception towards the activity-based approach of teaching and learning plane geometry, content analysis of the responses of students on the perception questionnaires indicated that females had a lower than males perception towards this approach. But in the focus group discussion there was no such differences in students’ perception towards the activity-based approach of teaching and learning plane geometry based on gender. Therefore, the supporting source of the perception difference between females and their male counterparts might be during the teaching and learning process where some of the girls complained that their male counterparts were not good enough as to help them learn. This necessitated the restructuring of some of the groups from lesson four which was almost too late since only six lessons were delivered.

But students' responses from the focus group discussions and the observations from the students' class activities by the researcher revealed that the perception of all students towards the activity-based approach was positive. Some of the responses from the students indicating their perception towards the activity-based approach were that this method is interesting, helps in sharing ideas and facilitates understanding of the concepts of plane geometry.

These findings supported the works of other researchers who studied the perception of students towards the activity-based approach in the teaching and learning situation. In a study conducted by Albadi (2019) to find out the impact of the activity-based approach of teaching on students' achievement, it came out that students in general have positive perceptions towards this approach. Specifically, students have the perception that, the activity-based approach of teaching and learning enhances understanding, improves students' achievement, helps weak students to develop, and encourages the creation of interesting teaching and learning atmosphere. Again, the activity-based approach of teaching and learning in the view of students encourages the creation of active learning environment, leads to conceptual understanding of concepts, creates interest towards learning and it is an interesting and useful method for learning in general (Parekh, Munjappa, Shined & Vaidya, 2018). These findings indicate that positive students' perception towards the activity-based approach of teaching and learning affects positively the achievement of learners. Therefore, the positive perception of students towards the activity-based approach by the experimental group in this study might have contributed to the improved achievement in the post-achievement test.

Chapter Summary

This research study sought to find out the effectiveness of the activity-based approach of teaching and learning on students' achievement in plane geometry. The perception of students towards the activity-based approach of teaching and learning plane geometry was as well determined. The activity-based approach of teaching and learning was used on the experimental group (School A) and the control group (School B) was taught through the traditional method. The findings of the study revealed that the activity-based approach of teaching and learning had significant positive effect on students' overall achievement in plane geometry. A comparative analysis of the covariance results showed however that the achievement difference of students in the post-achievement test between the experimental and the control groups were statistically significant. This indicates that students of the experimental group achieved more than their counterparts of the control group in the post-achievement test. Also, in the experimental within group analysis, the achievement difference between females and male counterparts was concluded statistically significant. The male students outperformed their female counterparts in the post-achievement test.

Students of the experimental group also showed a high positive perception towards the activity-based approach of teaching and learning plane geometry. Students' responses from the perception questionnaires, focus group discussions and the researcher's observation during the teaching and learning process all showed that both females and their male counterparts had positive perceptions towards this approach of teaching and learning. However, the male students had a more positive than female students' perception towards the activity-based approach of teaching and learning plane geometry. This indicates that perception of students towards the activity-based approach of teaching and learning had an influence on students' overall achievement since in the post-achievement test the male students had outperformed their female counterparts.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarised the research findings. The conclusions drawn from the study were also presented together with the recommendations for further research studies.

Summary

The purpose of the study was to investigate the effectiveness of the activity-based approach of teaching and learning plane geometry on students' achievement and perception of Senior High Students (SHS) in the Upper West region of Ghana. Three research questions as well as one research hypothesis were formulated to address the research objectives.

The concurrent embedded design employed in the study necessitated the collection of both quantitative and qualitative data to augment each other in addressing the research questions and hypothesis using teacher made pre-/post-achievement tests, questionnaires, observation and focus group discussion (FGD).

Purposive sampling technique was used to select the three Category A schools in the Upper West region of Ghana because they are relatively resourced than other category of schools in the region to take part in the study. The two participation schools that finally took part in the study together with the two intact classes were however selected through simple random sampling. The study participants were sampled from SHS 2 in two separate districts in the Upper West region of Ghana. In all, 84 participants were used in this study comprising 47 students from the experimental group and 37 from the control group.

Four different research instruments were used for the collection of data, teacher-made pre-/post-achievement tests, students' perception questionnaires, observation and focus group discussion guides. During the intervention, the experimental group was exposed to a three-week treatment with the activity-based approach and the traditional method was used on the control group for the same number of weeks. Pre-achievement test was conducted prior to the invention and the post-achievement test was administered after the intervention. Observations were made during the intervention and both the perception questionnaires and focus group discussion were conducted after the intervention. Four students volunteered and took part in the focus group discussion. Data from the four instruments were afterwards processed and analysed to help answer the formulated research questions and hypothesis.

Data sets for the study were described using descriptive statistics. Analysis of covariance was used to determine whether there existed any differences in achievement between students of the experimental group and their counterparts of the control group in learning plane geometry through the activity-based approach and the traditional method respectively. A paired sample T-test was also used to determine whether students of the experimental group differ in their achievement and perception in learning through the activity-based approach of teaching and learning plane geometry based on gender. A qualitative analysis of the pre-/post-achievement tests using descriptive statistics into various themes was carried out. Data from the focus group discussion and the observational guides were thematically analysed to support the quantitative data.

Findings

The major findings of the research study were drawn from the analysis of both the research questions and the research hypotheses. The results were thus presented based first on research question one and its related research hypotheses and followed by research questions two and three. The presentation of the research findings followed same trend.

Research question one (RQ1) aimed to explore the extent to which the activity-based approach and the conventional method of teaching and learning plane geometry affect students' achievement. The findings were that:

- Both the experimental and control groups had improved achievements in the post-achievement test over the pre-achievement test.
- Both females and their male counterparts of the experimental group improved significantly in their achievement in the post-achievement test than in the pre-achievement test.

The two research hypotheses (H_0 1 and H_0 2) formulated for this study were purported to indicate whether there was a statistically significant difference in the mean scores of the post-achievement test between the students taught with the activity-based approach based on gender and also between students of the experimental group taught through the activity-based approach and their counterparts taught through the traditional method respectively. The key findings were that:

- The male students of the experimental group performed better than their female counterparts in the post-achievement test.

- There was a statistically significant difference in achievement between the experimental and the control groups.
- The students of the experimental grouped had outperformed their counterparts of the control group in the post-achievement test.

Research question two (RQ2) aimed to explore how improvements in students' achievement in plane geometry is influenced by enhanced conceptual understanding of concepts gained through the activity-based approach of teaching and learning. The major findings were that:

- Students' conceptual understanding of concepts of plane geometry increased in the post-achievement test over the pre-achievement test leading to an improved students' overall achievement.
- Enhanced conceptual understanding of concepts of plane geometry led to a corresponding increase in remediation of misconceptions in the post-achievement test resulting in a corresponding improvement in students' achievement.
- The concept of quadrilateral recorded the highest number of 30 students who had conceptual understanding in the post-achievement test and chord theorem recorded the highest number of 12 students who had no conceptual understanding in the same test.

Also, research question three (RQ3) aimed to explore the perception of students of the experimental group towards the activity-based approach of teaching and learning plane geometry. It was found that:

- Both female and their male counterparts have positive perceptions towards the activity-based approach.

- The male students however had more positive perception towards the activity-based approach than their female counterparts.
- The positive perception resulted in an improvement in students' achievement in the post-achievement test.

Conclusions

The following conclusions were deduced from the findings of the research study. Firstly, it is concluded that when students are taught through the activity-based approach of teaching and learning plane geometry, it will lead to conceptual understanding, remediation of misconceptions and development of positive perception in students and the overall effect will be improvement in students' achievement.

Next, the findings of the study showed further that the activity-based approach of teaching and learning plane geometry had greater positive effect on students' achievement than the traditional approach though both methods led to improvements in students post-achievement test results. It was also noted that students learning through the activity-based approach showed more sustained interest in learning plane geometry than the traditional method. Therefore, when activity-based approach is used in the teaching and learning situation, students share ideas thereby increasing their conceptual understanding.

The study also revealed that in learning through the activity-based approach, male students had more positive perception towards this method, a reason they outperformed their female counterparts of the experimental group in the post-achievement test. It was therefore, noted that positive perception is one of the indicators of improved achievement in plane geometry.

Recommendations

Based on the findings of the research study, the following recommendations were made.

1. The activity-based approach (ABA) is recommended for the teaching and learning of plane geometry in particular and mathematics in general, since it may lead to conceptual understanding, remediation of misconceptions and development of positive perceptions in students and an improvement in students' achievement.
2. Workshops/seminars should be organised for teachers of mathematics on the need and how to use the activity-based approach in the teaching of the subject.
3. Female students should be encouraged and helped to develop more positive perceptions towards the study of mathematics since this is one of the factors that improves students' achievement in the subject.

The purposive sampling technique used in the selection of the participants has limited the generalizability of the recommendations of the study. The recommendations cannot be extended beyond the Category A schools since they were selected based on availability of resources. However, these recommendations can be used for schools with similar characteristics in other regions.

Suggestions for Further Research Studies

This study investigated the effectiveness of the activity-based teaching approach on students' achievement in plane geometry. The perception of students towards the activity-based approach was also explored. Future research studies can consider using the activity-based approach in teaching another domain of mathematics such as algebra.

Furthermore, this study can be replicated in other category of schools so that the findings can be compared with the findings of this current study.

Future research may consider using the activity-based approach and mathematical software such as geogebra in teaching different schools so that the findings can be compared.

Also, future research can look at replicating this study in two single sex schools (one female and the other male) so that the achievement in plane geometry can actually be compared based on gender.

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APPENDICES

APPENDIX A

Sample lesson plan 1 for the experimental group

Rubrics

Subject: Mathematics (Core) **Class:** General Arts 2A

Topic: Plane Geometry **Number on Roll:** 47

Subtopic: Cyclic Quadrilateral **(**Opposite angles of a cyclic quadrilateral are supplementary)

Duration: 2 hours **Date:** ………………………………..

Facilitator: Researcher

Related Previous Knowledge (RPK): Students can measure and read angles accurately

Teaching-Learning Materials (TLMs): Worksheets, protractor, calculator and marker board illustrations.

Learning Objectives (LO): By the end of the lesson, the student will be able to:

i. Discover that opposite angles of a cyclic quadrilateral are supplementary (i.e. add up to 180°).

ii. Use the theorem in answering related circle theorem questions.

Activity	Time in minutes	Teacher (T): Task	Student/s (Ss): Task	Interaction	Purpose
1	10	Introduction, grouping of students, giving out worksheets	Listen, form groups of two, collect worksheets	T <> Ss	Arouse interest in the study of the topic, stimulate background knowledge of topic, trigger participation, allowing weak students to benefit in the activity
2	10	Ask students to answer the lesson pre-test question, mark	Answer the question in their groups	T & Ss briefly discuss on whether it	Identify conceptual understanding of students

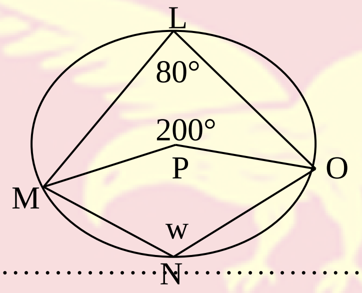
		it		is wrongly answered or not	& misconceptions before the intervention
3	40	Ask students to identify and measure the angles as contained in the worksheets and record their answers, go round and observe, help them discuss their findings	Ss actively engage in the activity using the worksheets and protractor, discuss their findings with other students	T assists Ss who have difficulty in identifying, measuring and reading angles, stating the required theorem	Assist Ss to accurately identify, measure, and read the required angles, state the required theorem
4	50	Let ss answer the illustrative examples on the worksheet for whole class discussion	Ss answer the questions and through marker board illustrations discuss their answers	T and ss discuss the answers	Determine whether ss can apply the theorem
5	10	Let students answer the post-lesson test, take it for marking, also tell them the next lesson to be taught	Ss in their groups answer the test, prepare on the next lesson	T <> ss	Determine students' conceptual understanding and misconceptions

APPENDIX B

Sample Worksheet for Lesson Plan 1

Activity 1 (10 minutes)

Find the value of w in the diagram if P is the centre of the circle and the reflex angle MPO is 200°.



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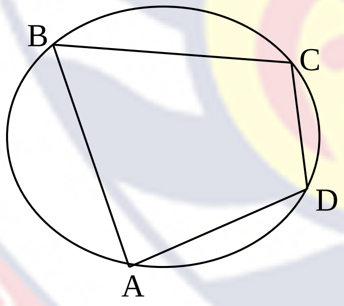
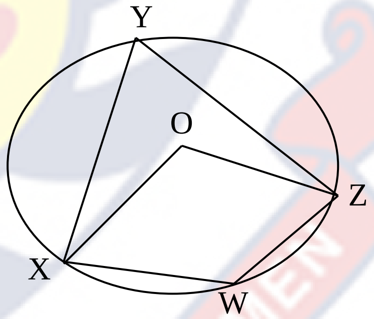
Activity 2 (40 minutes)

Measure the angles as indicated in the diagrams if O is the centre of the circle:





Angle ABC………..

Angle CDA…………

Angle BAD………..

Angle BCD…………

Angle XWZ……………..

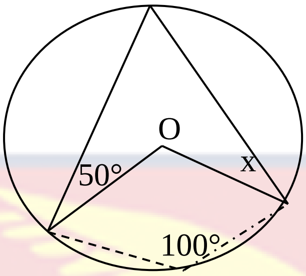
Angle XYZ……………..

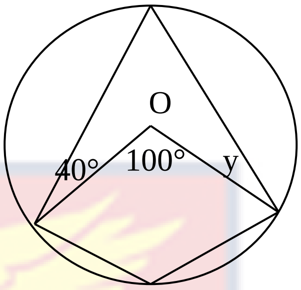
Angle XOZ……………..

Reflex < XOZ …………

Activity 3 (50 minutes)

Find the values of the letters indicated if O is the centre of the circles.





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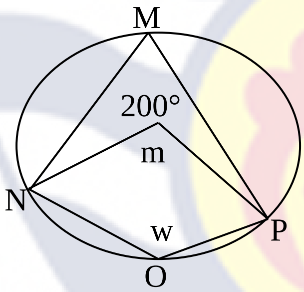
Activity 4 (10 minutes)

Find the values of m and w in the diagram if m is the centre of the circle.



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APPENDIX C

Sample lesson plan 2 for the experimental group

Rubrics

Subject: Mathematics (Core) **Class:** General Arts 2A

Topic: Plane Geometry **Number on Roll:** 47

Subtopic: Chord theorem **(**The angle subtended at the centre of a circle is twice the one subtended at the circumference by the same chord)

Duration: 2 hours **Date:** ………………………………..

Facilitator: Researcher

Related Previous Knowledge (RPK): Students are familiar with the theorem that opposite angles subtended by the same chord at the circumference of a circle is supplementary.

Teaching-Learning Materials (TLMs): Worksheets, protractor, calculator and marker board illustrations.

Learning Objectives (LO): By the end of the lesson, the student will be able to:

i. Discover that the angle subtended at the centre of a circle is twice the one at the circumference if created by the sane chord.

ii. Use the theorem in answering related circle theorem questions.

Activity	**Time in minutes**	**Teacher (T): Task**	**Student/s (Ss): Task**	**Interaction**	**Purpose**
1	10	Introduction, grouping of students, giving out worksheets	Listen, form groups of two, collect worksheets	T <> Ss	Arouse interest in the study of the topic, stimulate background knowledge of topic, trigger participation, allowing weak students to benefit in the activity
2	10	Ask students to answer the lesson pre-test question, mark	Answer the question in their groups	T & Ss briefly discuss on whether it	Identify conceptual understanding of students

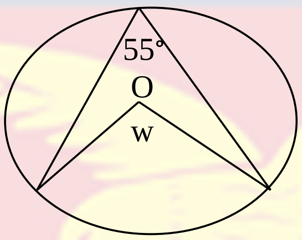
		it		is wrongly answered or not	& misconceptions before the intervention
3	40	Ask students to identify and measure the angles as contained in the worksheets, record their answers, go round and observe, help them discuss their findings	Ss actively engage in the activity using the worksheets and protractor, discuss their findings with other students	T assists Ss who have difficulty in identifying, measuring and reading angles, stating the required theorem	Assist Ss to accurately identify, measure, and read the required angles, state the required theorem
4	50	Let ss answer the illustrative examples on the worksheet for whole class discussion	Ss answer the questions and through marker board illustrations discuss their answers	T and ss discuss the answers	Determine whether ss can apply the theorem
5	10	Let students answer the post-lesson test, take it for marking, also tell them the next lesson to be taught	Ss in their groups answer the test, prepare on the next lesson	T <> ss	Determine students' conceptual understanding and misconceptions

APPENDIX D

Sample Worksheet for Lesson Plan 2

Activity 1 (10 minutes)

Find the value of w in the diagram if O is the centre of the circle



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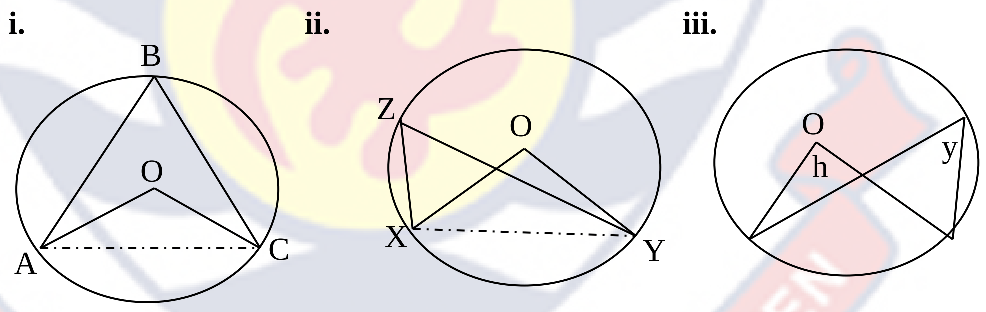
Activity 2 (40 minutes)

Measure the angles as indicated in the diagrams:

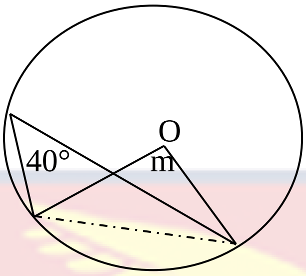


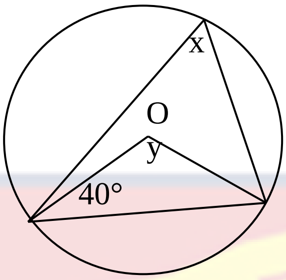
Angle AOC……….. Angle XOY………… Angle h………..

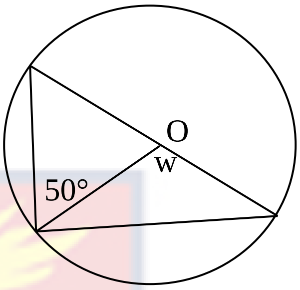
Angle ABC……….. Angle XZY………… Angle y………..

Activity 3 (50 minutes)

Find the value of the letters indicated if O is the centre of the circles.

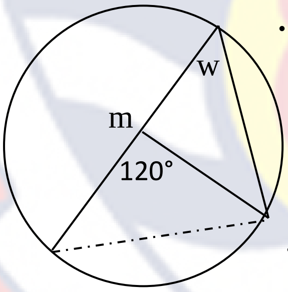






Activity 4 (10 minutes)

Find the value of w in the diagram if m is the centre of the circle.



APPENDIX E

Sample lesson plan for the control group

Rubrics

Subject: Mathematics (Core) **Class:** General Arts 2A

Topic: Plane Geometry **Number on Roll:** 37

Subtopic: Cyclic Quadrilateral **(**Opposite angles of a cyclic quadrilateral are supplementary)

Duration: 2 hours **Date:** ………………………………..

Facilitator: Researcher

Related Previous Knowledge (RPK): Students can answer questions on the theorem that two or more angles formed at the circumference of the circle in the same segment by the same chord are equal.

Teaching-Learning Materials (TLMs):

Calculator and marker board illustrations.

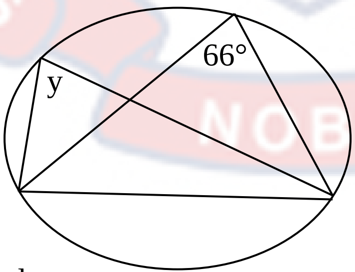
Learning Objectives (LO): By the end of the lesson, the student will be able to:

i. Deduce that opposite angles of a cyclic quadrilateral are supplementary (i.e. add up to 180°).
ii. Use the theorem in answering related circle theorem problems.

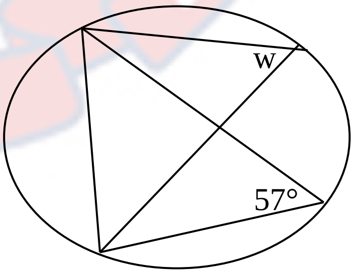
Introduction (20 minutes):

Teacher: Revise students related previous knowledge (RPK) by asking them to find the values of the letters indicated in the following diagrams and give reasons:

i.



ii



Expected answers:

i. $y = 66°$ (angles formed in the same segment by the same chord are equal)
ii. $w = 57°$ (angles formed in the same segment by the same chord are equal)

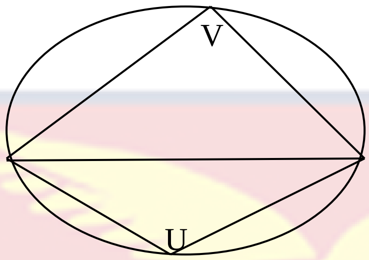
Development (60 minutes):

Step 1

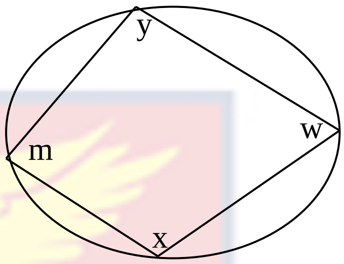
Activity One

Teacher: Draw the following diagrams on the marker board

i.



ii.



Activity Two

Teacher: Guide students through question and answer as well as demonstration methods to come out with the theorem that angles formed by the same chord in opposite segments are supplementary (i.e. opposite angles of a cyclic quadrilateral are supplementary or add up to 180°).

Expected Response:

i. U + V = 180°

ii. m + w = 180°

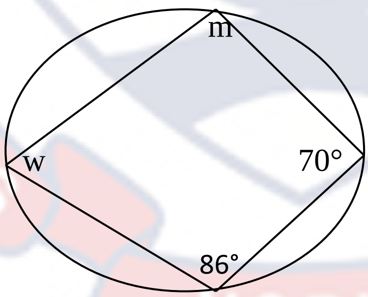
iii. y + x = 180°

Summary: Opposite angles of a cyclic quadrilateral are supplementary.

Step 2

Teacher: Guide students through question and answer as well as demonstration methods to solve the following problems by finding the values of the letters indicated in the diagrams and give reasons.

i



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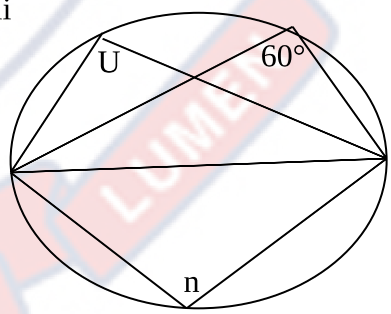
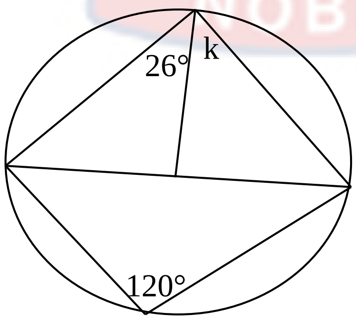
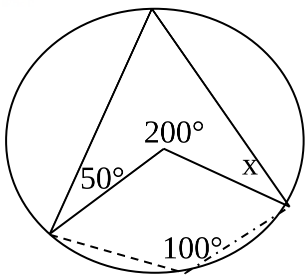


iii



iv



Expected Response:

i. α. m = 86° ii. α u = 60° iii. 26° + k = 60°

β. w = 70° β. n = 120° → k = 34°

iv. 200° + 80° + 50° + x = 360°.

→ x + 330° = 360°

→ x = 360° - 330°

→ x = 30°

Step 3 (10 minutes):

Teacher: Through question and answer method guide students to clarify areas they did not understand.

Students: Ask questions on areas they did not understand for clarification.

Closure (10 minutes):

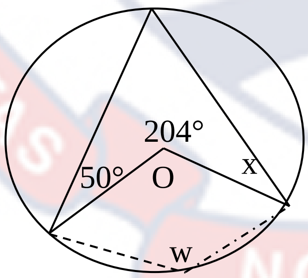
Teacher: Guide students through question and answer method to summarise the lesson of the day.

Expected Response: Opposite angles of a cyclic quadrilateral add up to 180°.

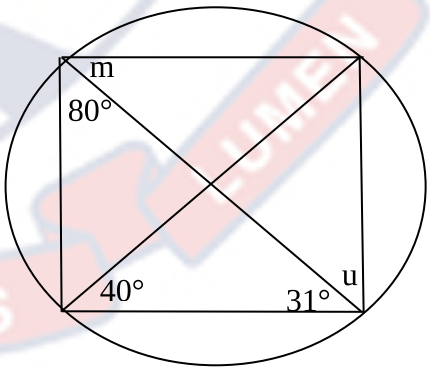
Evaluation (20 minutes):

Study carefully the following diagrams and find the values of the letters indicated if O is the centre of the circles and give reasons.

i.



ii.



Remarks:

APPENDIX F

PRE-ACHIEVEMENT TEST

This section of the instrument contains **five (5) questions** on plane geometry.

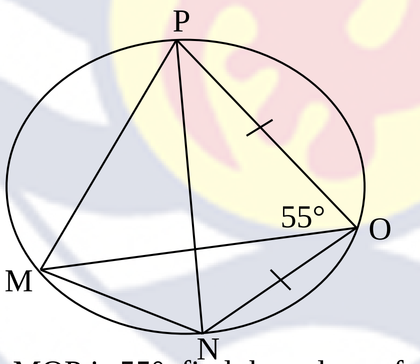
You are expected to **answer all the questions** on this paper.

Each question carries **8 marks**.

The total mark (s) is forty (40). The duration of the test is **sixty (60) minutes**.

Marks will be awarded for clarity of expression and orderly presentation of answers. **Indicate on the answer booklet whether you are male or female and state your programme of study.**

Q1. (a) In the diagram, M, N, O and P are points on the circle. |PO| = |NO| and line PN is the diameter of the circle.

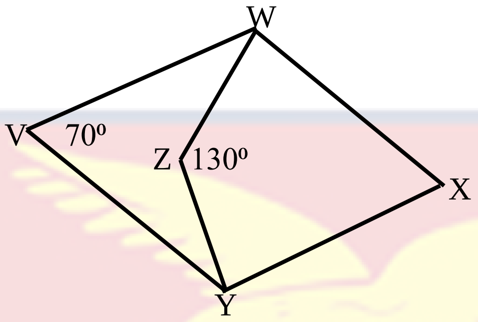


If angle MOP is 55°, find the values of

i) < PNO

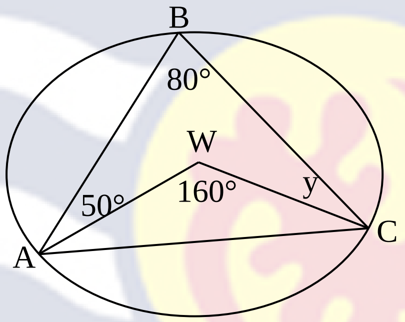
ii) < MON

Q1. (b) In the diagram, VWXY is a rhombus and WXYZ is a kite, angle WVY = 70° and angle WZY = 130°.



Calculate for the value of angle ZYX.

Q2. (a). Two triangles are inserted into a circle as indicated.



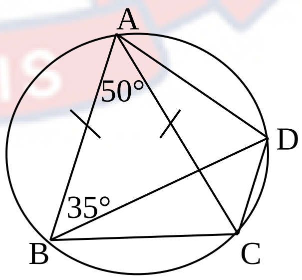
Find the value of angle y.

Q2. (b) In the diagram, A, B, C and D are points on the circle. |AB| = |AC|. Angle BAC = 50° and angle ABD = 35°.

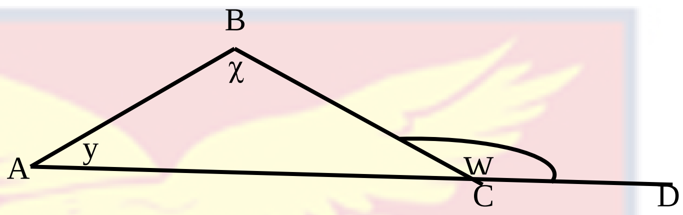
Calculate for the angles;

i. CBD

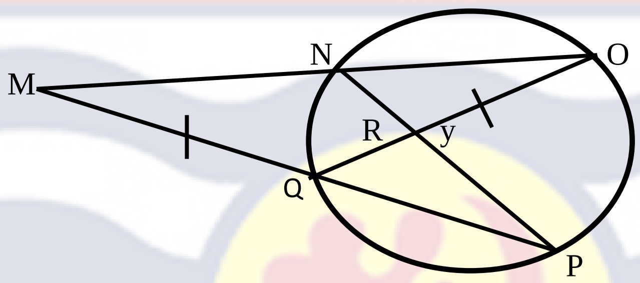
ii. CDB



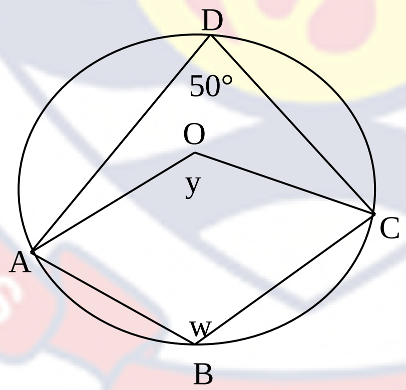
Q3. (a) In the diagram, ABC is a triangle and angle BCA is 50°. Find a mathematical equation connecting w, x and y. Hence, calculate for the values of x and y if the difference between them is 10° and x is greater than y.



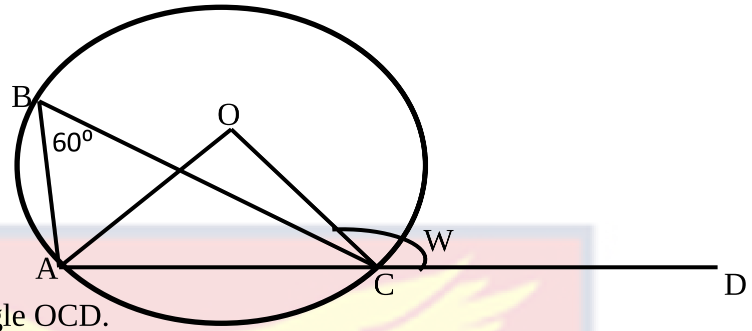
Q3. (b). In the diagram, |QM| = |QO| and angle MNR = angle MQR = 130°. Find the value of angle ORP.



Q4. (a) Two quadrilaterals ABCD and OABC are inserted into a circle with centre O as shown. Find the values of y and w.



Q4. (b) In the diagram, O is the centre of the circle and angle ABC = 60°.

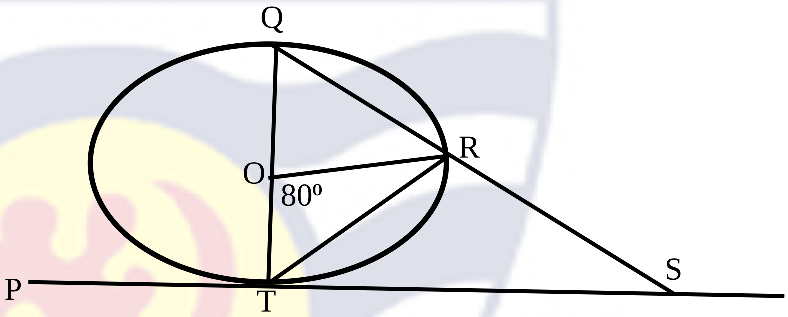


Find the value of angle OCD.

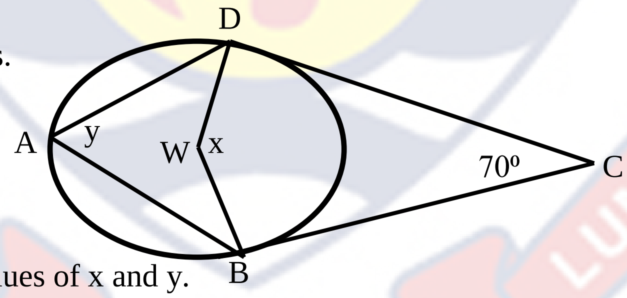
Q5. (a) In the diagram, O is the centre of the circle, |PS| is a tangent to the circle at the point T and |SQ| is a straight line. Angle ROT is 80°. Find the values of:

i. < QRO.

ii. < QST.



Q5. (b) In the figure, W is the centre of the circle, < BCD = 70°, |CB| and |CD| are tangents.



Find the values of x and y.

APPENDIX G

POST-ACHIEVEMENT TEST

This section of the instrument contains **five (5) questions** on plane geometry.

You are expected to **answer all the questions** on this paper.

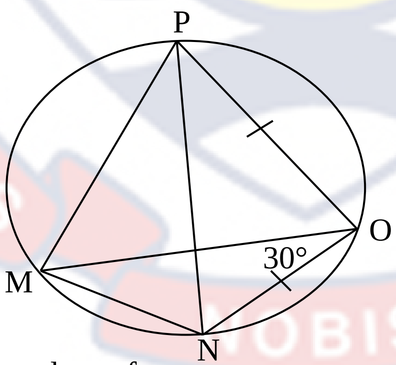
Each question carries **8 marks**.

The total mark (s) is forty (40). The duration of the test is **sixty (60) minutes**.

Marks will be awarded for clarity of expression and orderly presentation of answers.

Indicate on the answer booklet whether you are male or female and state your programme of study.

Q1. (a) Letters M, N, O, and P are points on a circle as shown. |ON| = |OP| and |PN| is the diameter.

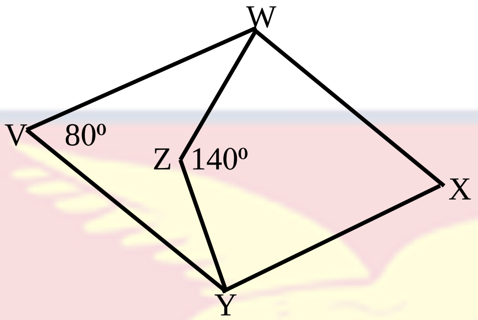


Find the values of

i) < MOP

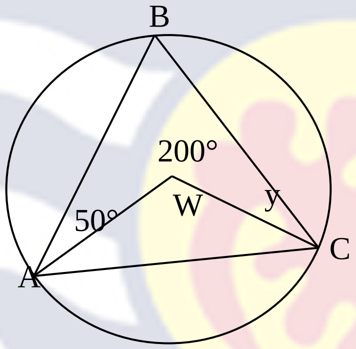
ii) <NPO

Q1. (b) In the diagram, VWXY is a rhombus and WXYZ is a kite, angle WVY = 80º and angle WZY = 140º.



Calculate for the value of angle ZWX.

Q2. (a). Two triangles with a common base |AC| are inserted into a circle as indicated.



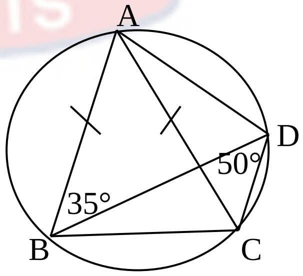
If the reflex angle AWC is 200°, find the value of y.

Q2. (b) In the diagram, A, B, C and D are points on the circle. |AB| = |AC|. Angle BDC = 50° and angle ABD = 35°.

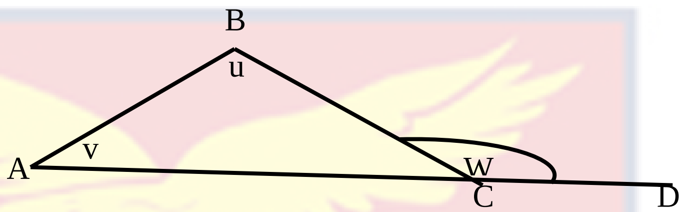
Calculate for the values of;

i. <CBD

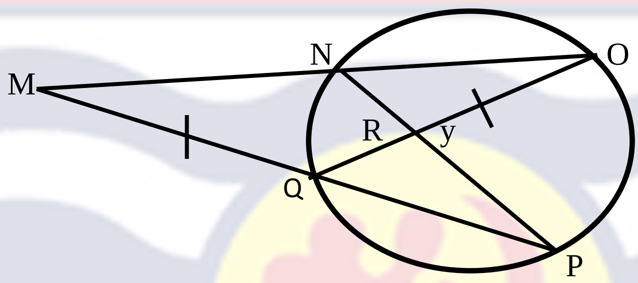
ii. <BAC



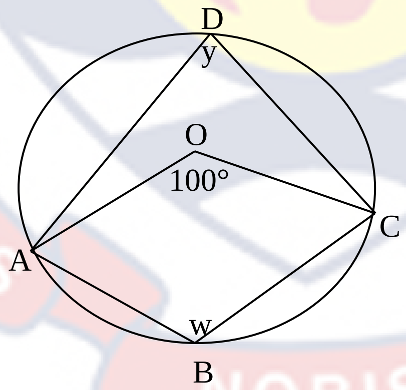
Q3. (a) In the diagram, ABC is a triangle and angle BCA is 60º. Find a mathematical equation connecting w, u and v. Hence, calculate for the values of u and v if the difference between them is 20° and u is greater than v.



Q3. (b). In the diagram, |QM| = |QO| and angle ONP = angle OQP = 50°. Find the value of angle ORP.

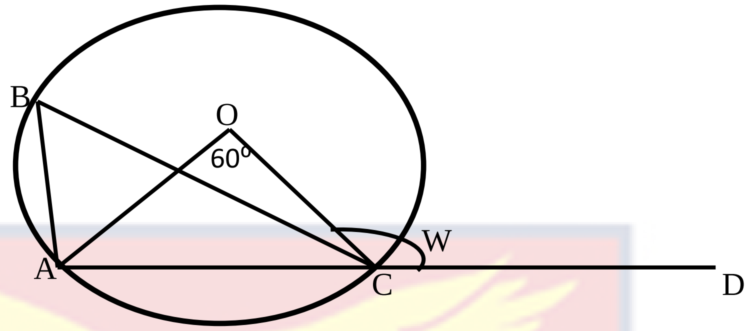


Q4. (a) Two quadrilaterals ABCD and OABC are inserted into a circle with centre O as shown.



Find the values of the letters y and w.

Q4. (b) In the diagram, O is the centre of the circle and angle ABC = 60º.

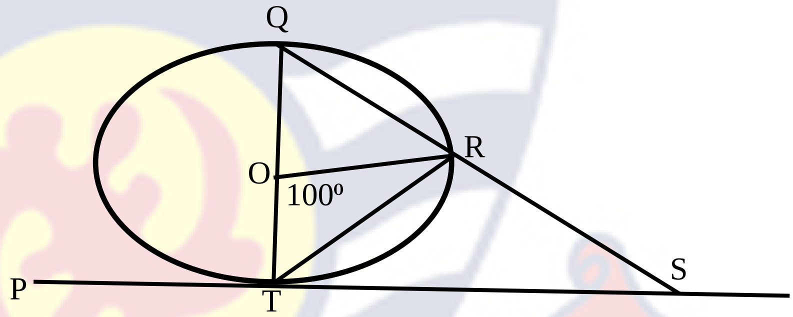


Find the value of angle OCD.

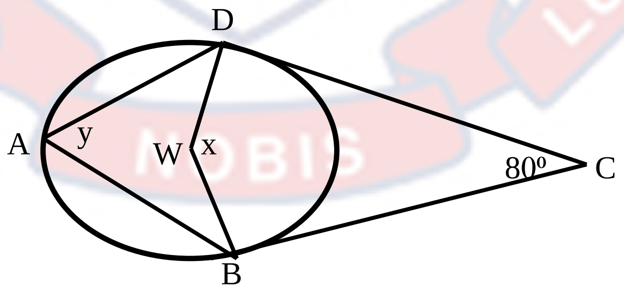
Q5. (a) In the diagram, O is the centre of the circle, |PS| is a tangent to the circle and |SQ| is a straight line. Angle ROT is 100º. Find the value of:

i. < QRO.

ii. < QST.



Q5. (b) In the figure, W is the centre of the circle, < BCD = 80º, |CB| and |CD| are tangents.



Find the values of x and y.

APPENDIX H

UNIVERSITY OF CAPE COAST

COLLEGE OF EDUCATION STUDIES

FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

QUESTIONNAIRE

PART I

Please provide the following demographic information.

1. What is your sex? (Tick [√] one only)

[] Male

[] Female

2. What is your programme of study?........... ……………………..

PART II

Express your opinion on the activity-based approach of teaching and learning plane geometry using the following rating scale: **Strongly Agree =** SA; **Agree = A; Neutral = N; Disagree =** D; and **Strongly Disagree = SD;** and choose the one response that comes closest to describing your opinion. (Tick [√] only one).

Item No.	**Student's Perception towards the Activity-Based Approach of Learning Geometry**	**SD**	**D**	**N**	**A**	**SA**
1	The lessons were generally interesting					
2	The activities in the lessons helped me to understand the lessons better					
3	Discussions in the group helped me to learn plane geometry better					
4	The activities in the lessons helped me to identify theorems and properties better					
5	I found the lessons exciting					
6	The use of the worksheets made the lessons interesting					
7	I am now interested in learning the topic					

	plane geometry through the activity-based approach					
8	The arrangement of the lessons was logical, clear and appropriate					
9	The activity-based approach should be used in teaching all topics in mathematics					
10	The content of the lessons was well delivered					
11	The lessons helped me to understand concepts I found difficult to understand before					
12	The use of worksheets in teaching plane geometry is a good approach					
13	I can now read and interpret theorems of plane geometry better					
14	The examples given in the lessons have enhanced my understanding of the topic					
15	Plane geometry should always be taught through the activity-based approach					
16	All other topics in mathematics should be taught through the activity-based approach					
17	The different types of activities I was engaged in helped me to remember what I learnt better					
18	The activity-based approach should be used in teaching all other subjects					

APPENDIX I

UNIVERSITY OF CAPE COAST

COLLEGE OF EDUCATION STUDIES

FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

FOCUS GROUP DISCUSSION GUIDE

(a) What is your general view on the activity-based approach of teaching and learning plane geometry?

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(b) What is your view on putting you into groups to work together?

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(c) What are some of the challenges you encountered in learning through the activity-based approach?

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d) Which areas of plane geometry don't you understand after the teaching?

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e) Which theorems and properties of plane geometry can you say you understood better?

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APPENDIX J

UNIVERSITY OF CAPE COAST

COLLEGE OF EDUCATION STUDIES

FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF MATHEMATICS AND ICT EDUCATION

OBSERVATIONAL GUIDE

1. What were some of the challenges students' encountered in learning through the Activity-Based Approach?

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2. Students took part in the whole class discussions………..……………
3. Were some misconceptions identified? ………………………………
4. If yes, what misconceptions were they?

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5. Were some of the misconceptions identified remediated in the whole class discussion process? ....
6. If yes, state some of them.

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7. Did students show conceptual understanding of the geometric concepts? ....

8. If yes, in what way do they exhibit conceptual understanding?

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9. What was students' general disposition in learning through the Activity-Based Approach? ……………………………………………..

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10. Which areas of plane geometry presented problems to the students?

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