EFFECTS OF JIGSAW IV COOPERATIVE LEARNING ON INTEREST AND ACADEMIC PERFORMANCE OF SECONDARY SCHOOL STUDENTS IN GEOMETRY IN KADUNA STATE, NIGERIA

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ZARIA

APRIL, 2016

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN MATHEMATICS EDUCATION DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF EDUCATION, AHMADU BELLO UNIVERSITY, ZARIA

APRIL, 2016

DECLARATION

I Joseph Majiyebo TIMAYI (M.Ed/Educ/5584/2011-2012) declare that this dissertation entitled "Effects of Jigsaw IV Cooperative Learning on Interest and Academic Performance of Secondary School Students in Geometry in Kaduna State" has been conducted by me in the Department of Science Education, Ahmadu Bello University Zaria under the supervision of Prof. C. Bolaji and Prof. Y.K. Kajuru. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of the thesis was directly presented for another degree or diploma at any University.

_____ _____

Joseph Majiyebo TIMAYI Date
Reg. No.: M.Ed/Educ/5584/2011-2012

CERTIFICATION

This dissertation entitled “Effects of Jigsaw IV Cooperative Learning on Interest and Academic Performance of Secondary School Students in Geometry in Kaduna State " byJoseph Majiyebo TIMAYI (M.Ed/Educ/5584/2011-2012), met the regulations governing the award of Masters Degree in Mathematics Education of Ahmadu Bello University, Zaria, and is approved for its contribution to the knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to my wife Cecilia Timayi and my children David and Daniel Timayi.

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ABBREVIATIONS

EG Expert Group

ES Expert Sheet

GII Geometry Interest Inventory

GPT Geometry Performance Test

GSS Government Secondary School

HG Home Group

J4CLS Jigsaw IV Cooperative Learning Strategy

MANMathematics Association of Nigeria

NECO National Examination Council

NMC National Mathematical Centre

SSS Senior Secondary School

WAEC West African Examination Council

OPERATIONAL DEFINITIONS OF TERMS

Cooperative Learning: This is an instructional method in which the teachers organizes students into small groups, who then work together to help one another learn academic content (Johnson, Johnson & Smith, 2014).

Expert Group: A group in the J4CLS that is meant to learn and master only a portion of the entire material or topic within a stipulated time frame.

Expert Sheet: This is a list, figures, sub-topics or materials which is part of the entire material students in the expert group (EG) are expected to master and in turn teach the members of their home group (HG). Each EG has a different expert sheet (ES).

Geometry: A branch of mathematics concerned with the shape of individual objects, spatial relationships among various objects, and the properties of surrounding space (Heilbron, 2014).

Home Group: This is the basic group which every learner must belong to before proceeding to an Expert Group to master an area from the entire material and return again to teach other members of the group.

Interest: It is a psychological state characterized by a high level of attention, intensive effort, and prolonged engagement with an activity and accompanied by feelings of pleasure and a sense of achievement which is assumed to be derived from learner – content interaction (Hid & Renninger, 2006).

Jigsaw IV Cooperative Learning: This is a cooperative learning strategy developed by Holliday (2002), where students are assigned to a heterogeneous group (using some coding system) called the Home Group (HG) based on the number of items in the content to be learnt. All the members in the HGs with the same code are grouped again into different Expert Groups (EG) where they learn only a part of the entire material content called the Expert Sheet (ES). They return to their home group, teach all their group members and take quizzes all based on the original material. Finally, the teacher re-teaches any material which was misunderstood after the individual assessment process.

Lecture Method: This is a traditional teaching method considered to be an educational essentialism.It is simply a chalk-talk approach in which students are passive learners.

ABSTRACT

This study examined the Effects of Jigsaw IV Cooperative Learning Strategy (J4CLS) on Interest and Academic performance of Secondary School Students in Geometry in Kaduna State, Nigeria. The study is an attempt to solve the persistent low interest and poor performance of students in geometry at the senior secondary school level. The study was guided by four research questions and four hypotheses. The quasi experimental research design involving two groups (one experimental and the other control) was used. The population of the study comprised of senior secondary school year two (SS2) students of the public secondary schools in Zaria Educational Zone of Kaduna State. Four (4)coeducation schools out of nine (9) were selected by the simple random sampling method and pretested. The result obtained was subjected to the analysis of variance (ANOVA) and the Scheffe's test. Three schools were found to have equivalent abilities; consequently, two schools were selected by the simple random sampling as the schools sampled for the study. The sample of students for the study comprised of 72 students in each school from two intact classes (144 students) selected by the simple random sampling technique from the SS2 arm in the respective schools. Two instruments:Geometry Performance Test (GPT) and Geometry Interest Inventory (GII) were used for data collection. The research questions were answered by the mean, standard deviation and mean rank scores while the research hypotheses were analyzed using the t-test, Kruskal-Wallis test and Dun-Bonferroni Post hoc tests at $P \leq 0.05$ level of significance by the aid of the computer software Statistical Packages for Social Sciences (SPSS version 21). The results obtained showed a significant difference in performance in favour of student exposed to the J4CLS. The results also revealed no significant difference in performance of male and female students when exposed to the J4CLS. The result further revealed a significant difference in interest level in favour of student exposed to the J4CLS but no significant difference was found in interest level between male and female students in the experimental group and between male and female students in the control groups respectively. The study concludes that the J4CLS is effective in the teaching and learning of geometry and it is a gender friendly teaching method. Based on the findingsrecommendations were made such as teachers should employ the J4CLS in the teaching of geometry in senior secondary schools to enhance students' interest and performancein it. Also, students should be encouraged by their teachers to participate in the J4CLS because it is a result oriented strategy that has the potential of improving their performance and interest in mathematics. Finally, workshops and seminars for mathematics and science based teachers should be organized by the Ministry of Education for each educational zone in Kaduna State on the use of the J4CLS in classrooms.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

Geometry is a branch of mathematics that is concerned with the shape of individual objects, spatial relationships of various objects, and the properties of surrounding space (Heilbron, 2015). Geometry is found everywhere: in art, architecture, engineering, robotics, land surveys, astronomy, sculptures, space, nature, sports, machines, cars and much more and hence, tagged the bedrock of engineering and technological development (Adolphus, 2011).The study of geometry is very important because it has everyday applications and hasbeen proven to facilitate the development of skills of visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof (Jones, 2002; Iji, Ogbole & Uka, 2014).

Literatures have consistently reported low performance of students in mathematics; but geometry is a core difficult area in mathematics, which contributes to this malady. It has been observed that students dreaded this aspect of mathematics and only very few candidates attempt questions on geometry (Adolphus, 2011; Ali, Bhagawati & Sarmah, 2014). The problems identified in the teaching and learning of geometry at the secondary school level include the following:weak teachers' background, weakstudents' foundation, poor teachers' preparation due to high workload, low students' interest and poor understanding of geometry concepts. Other problems are poor problem solving skills,lack of proper guidance to construction and proof of geometric figures,anxiety for geometrical figures and poor teaching methodology (Chiason, Kurumeh & Obida, 2010; Adolphus, 2011; Ali et al, 2014).

The teaching and learning of geometry in secondary schools in Nigeria follows the conventional method (lecture) of instruction, which have been found to inhibit development of students' intuition, imagination and creative abilities. It is also deemed restricted to some degree and its classroom settings is teacher-centered where the teacher often talks to the students instead of encouraging them to interact, ask questions or make them understand the lesson thoroughly (Anyichie & Onyedike, 2012). Hence, there is a need to try out other teaching methods such as the cooperative learning strategy.

The J4CLS was developed by Holliday (2002). It involves assigning students to a heterogeneous group (using some coding system) called the Home Group (HG) based on the number of items in the content to be learnt. All the members in the HGs with the same code are grouped again into different Expert Groups (EG) where they learn only a part of the entire material content called the Expert Sheet (ES). They return to their home group, teach all their group members and take quizzes all based on the original material. Finally, the teacher re-teaches any material which was misunderstood after the individual assessment process.

Globally, there have been debates on students' performances in mathematics with respect to gender(Stoet & Geary, 2013). Studies such as James (2007), Ali et al (2010)and Atovigba, Vershima, O'Kwu and Ijenkeli (2012) observed that male students outperform their female counterpart in mathematics. Thorough studies such as Else-Quest, Hyde and Linn (2010) and Linderberg, Hyde, Petersen and Linn (2010) reported that gender differences among male and female is closing and both male and female perform similarly. In the study of geometry, the same situation and result holds in terms of gender achievement and performance. Atebe (2008), Yang and Chen (2010) submitted that male

students performed better than their female counterpart did by exhibiting better spatial abilities while other studies like Etukudo (2002) and Iji et al (2014) found no significant difference in the performance of students in geometry and hence their mathematical performance at the secondary school level.Based on the background above, this study investigated the effects of Jigsaw IV cooperative learning strategy on interest and academic performance of secondary school students in geometry in Kaduna State, Nigeria.

1.2 Statement of the Problem

The issue of lack of interest and poor performance among students in geometry in secondary schools has continue to affect the academic performance of students in mathematics despite the importance of the subject to nation building and development. Studies such as Iji *et al* (2014) and Charles-Ogan (2014) asserted that secondary school students'performance is less than 50 percent in geometry for the past decades. Also, the Chief Examiners report for WAEC (2009 - 2014) and NECO (2014) expressed worries over the low achievement of students in geometry and other areas of mathematics which they attributed to weakness and difficulty in understanding geometrical concepts, lack of confidence, poor teaching methods, poor retention and interest in mathematics.

The low performance and lack of interest among students in geometry is also observed by Kurumeh, Onah and Mohammed (2012) who asserted that it is a function of the instructional method adopted by the teacher. The instructional method employed by the teacher plays an important role in the acquisition of instructional content for meaningful learning and development of necessary skills. Nigerian secondary school classrooms are predominantly dominated by the conventional method of instruction, which does not encourage students-student's interaction. It is teacher-centered instructional methods that

make students passive with less interaction. The lack of active participation of students intheir learning was also indicted for students' poor performances in geometry (Gambari & Olumori, 2013).

Research in many areas of education has shown that the methods of teaching utilized by the teacher is an important factor in students' learning and subsequent performance in examinations (Obeka, 2014). Hence there is the need to try out other method to salvage the situation. Based on the above, this study investigatedthe effects of Jigsaw IV cooperative learning strategy on interest and academic performance of secondary school students in geometry in Kaduna State, Nigeria.

1.3 Objectives of the Study

The objectives of the study are to:

i. investigate the effect of Jigsaw IV cooperative learning strategyon students' academic performance in geometry.
ii. determine the level of interest in geometry of students when exposed to the Jigsaw IV cooperative learning strategy.
iii. investigate the performance of male and female students when exposed to the Jigsaw IV cooperative learning strategy.
iv. examinethe level of interest of male and female students when exposed to the Jigsaw IV cooperative learning strategy.

1.4 Research Questions

The following research questions were formulated as guide to the study:

i. What is the difference in mean performance scores of students taught geometry using the Jigsaw IV cooperative learning strategy and those taught by the lecture method?

ii. What is the difference in mean performance scores of male and female students taught geometry using the Jigsaw IV cooperative learning strategy?

iii. What is the difference in interest level of students taught geometry using the Jigsaw IV cooperative learning strategy and those taught by the lecture method?

iv. What is the difference in interest level of male and female students when taught geometry using the Jigsaw IV cooperative learning strategy?

1.5 Null Hypotheses

The following null hypotheses were tested at $P \leq 0.05$ level of significance in the study.

H_{01}: There is no significant difference in the mean performance scores of students taught geometry using the Jigsaw IV cooperative learning strategy and those taught using the lecture method.

H_{02}: There is no significant difference in the mean performance scores of male and female students taught geometry using the Jigsaw IV cooperative learning strategy.

H_{03}: There is no significant difference between the interest level of students taught geometry using the Jigsaw IV cooperative learning strategy and those taught by the lecture method.

H_{04}: There is no significant difference between the interest level of male and female studentstaught geometry using Jigsaw IV cooperative learning strategy and the lecture method.

1.6 Significance of the Study

The significance of this study was discussed under the implications and applications of the research to students, teachers, the government and other researchers in the following way:

1.6.1 Implications of the study

This research is significant to the extent that it is hoped that it will help reduce poor performance and achievement in mathematics in Nigerian secondary schools, bring about better interest and retention in mathematics. Also, the government can promote national unity, peace and tolerance through cooperative learning in schools.

The society will benefit from the study; this is because, if the study brings about an improvement in students' performance and interest in mathematics, many students in tertiary institutions will study the subject and its related courses. This will enhance our nation's potential in the use of science and technology for capacity building and sustainable development. In addition, researchers can use the findings of the study as a foundation for their research. The researcher believes that the findings of the study will add new knowledge to the existing literature.

It is also hoped that science and research based organization like Science Teachers Association of Nigerian (STAN), Mathematics Association of Nigeria (MAN), National Education Research and Department Council (NERDC) etc. will find this study useful. Other researchers also can use this study in their own work thereby exploring and discovering newer grounds.The researcher believes that the findings of the study will add new knowledge to the existing literature.

1.6.2 Applications of the study

Students will hopefully have better test scores and achievement when exposed to the Jigsaw IV cooperative learning strategy (J4CLS). This study will be of immense benefit to teachers who will find the J4CLS fun, result oriented and applicable in their teaching of mathematical concepts than the convention method has been. Hence, teachers can therefore employ the J4CLS as a guide for developing a wide range of classroom activities, which is capable of making learning more meaningful.

It is also hoped that science and research based organization like Science Teachers Association of Nigerian (STAN), Mathematics Association of Nigeria (MAN), National Education Research and Department Council (NERDC) etc. will find this study useful. Other researchers also can use this study in their own work thereby exploring and discovering newer grounds.

1.7 Basic Assumptions

In this research work, the following assumptions are made:

i. The students have some foundation of geometry from their previous classes that is useful in the present study.

ii. Students can work together in small groups as required in the J4CLS.

iii. Teachers are less competent in their mastery of geometry in secondary schools.

iv. The school environment is conducive for the teaching and learning of geometry using the cooperative learning strategy.

1.8 Scope/ Delimitation of the Study

This research was delimited to investigating the effects of cooperative learning strategy on the interest and academic performance of senior secondary school students in geometry in Kaduna State. The study was restricted to senior secondary year two (SS2) students drawn from two (2) public senior secondary schools in Zaria Educational Zone of Kaduna State. The study will not cover all aspects of geometry and mathematics syllabus for senior secondary schools. Students of JSS1, JSS3, SS1 and SS3 are not part of the study.

The research will not examine teachers background in geometry, preparation for classes and workload. Other aspects that will not be covered in the study include: students' problem solving skills, anxiety for geometrical figures and antecedents of weak geometry foundation.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter reviewed literature for the study the effects of Jigsaw IV cooperative learning strategy on interest and academic performance of secondary school students in geometry in Kaduna State, Nigeria. The aim of the study was to determine the effect of Jigsaw IV cooperative learning on the academic performance and interest of student in geometry. This is because geometry has been a sub-topic in mathematics where students have performed poorly and sometimes avoid completely in terminal and standardized examinations. The discussion was done under the following sub-headings:

2.2 Theoretical framework

2.3 Teaching of Geometry at Secondary Schools

2.4 Mathematics Teaching Methods

2.5 Conventional Method of Teaching Geometry in Secondary Schools

2.6 Cooperative Learning Strategy

2.7 The Concept of Interest and Academic Performance in Mathematics

2.8 Overview of Related Studies

2.9 Implications of Literatures Reviewed to the Present Study

2.2 Theoretical Framework

The theoretical basis for this study was anchored on the social learning theory by Slavin (2009). This is because cooperative learning is a student-centered instructional approach that employs various educational tactics and strategies that relate to the different

ways students think and learn. Strategies such as a jigsaw activity were designed around research that relates to a learning theory.

Slavin (2009) identified four theoretical perspectives on the achievement effects of cooperative learning. They are motivationalist, social cohesion, cognitive-developmental and cognitive-elaboration.

2.2.1 Motivational Perspectives

Motivational perspectives on cooperative learning posit that task motivation is the most important part of the process, believing that the other processes are driven primarily by motivation. From a motivation list perspective (Slavin, 2009), cooperative incentive structures create a situation in which the only way group members can attain their own personal goals when the group is successful. Therefore, to meet their personal goals, group members must both help their group mates to do whatever enables the group to succeed, and, perhaps even more importantly, to encourage their group mates to exert maximum efforts. In other words, rewarding groups based on group performance (or the sum of individual performances) creates an interpersonal reward structure in which group members will give or withhold social re-enforcers (e.g. praise, encouragement) in response to group mate's task - related efforts.

2.2.2 Social Cohesion Perspective

This theoretical perspective is somewhat related to the motivational; it holds that the effects of cooperative learning on achievement are strongly mediated by the cohesiveness of the group. It presupposes that the quality of the group's interactions is largely determined by group cohesion. In essence, students will engage in the task and help

one another learn because they identify with the group and want one another to succeed. This perspective is similar to the motivational perspective in that it emphasizes primarily motivational rather than cognitive explanations for the instructional effectiveness of cooperative learning. However, motivational theorists hold that students help their group mates learn primarily because it is in their own interests to do so. Social cohesion theorists, in contrast, emphasize the idea that students help their group mates learn because they care about the group.

2.2.3 Cognitive Perspectives

The cognitive perspective holds that interactions among students will in themselves increase student achievement for reasons that have to do with mental processing of information rather than with motivations. Cooperative methods developed by cognitive theorists involve neither the group goals that are the cornerstone of the motivationalist methods nor the emphasis on building group cohesiveness characteristic of the social cohesion methods. However, there are several quite different cognitive perspectives, as well as some, which are similar in theoretical perspective, but have developed on largely parallel tracks.

2.2.4 Developmental Perspectives

The fundamental assumption of the developmental perspective on cooperative learning is that interaction among learners around appropriate tasks increases their mastery of critical concepts. This agrees with with Lev Vygotsky's (1896 - 1934) developmental theory that placed a lot of emphasis on social interactions. Vygotsky's postulated the Zone of Proximal Development (ZPD) which is described as the distance between a child's

development as a result of independent learning and the potential higher level of development that the child could achieve through cooperative problem-solving with more capable peers. He opined that the collaborative activity among children promotes growth because children of similar ages are likely to be operating within one another's proximal zones of development, modeling in the collaborative group behaviors more advanced than those they could perform as individuals. Similarly, Piaget (1936) held that social-arbitrary knowledge, language, values, rules, morality, and symbol systems can only be learned in interactions with others. Peer interaction is also important in logical-mathematical thought in dis-equilibrating the child's egocentric conceptualizations and in providing feedback to the child about the validity of logical constructions.

This theoretical perspective on the achievement effects of cooperative learning provides the necessary explanation for understanding the strategy and how it works. This follows since the components of cooperative learning aredesigned to promote active learning to a diverse range of students, and are founded within the social learning theories.

2.3 Teaching of Geometry at Secondary Schools

The place of mathematics in any nation is crucial because it is linked with its development. In Nigeria, mathematics is one of the core subjects offered in the primary and secondary level of education. A society’s scientific and technological breakthrough is contingent on her citizen’s performances in the mathematical sciences (Shuaibu, 2012). Mathematics has continued to play a key role in shaping how individuals deal with activities that shape their livelihoods. As a logical language for expressing ideas, shapes, quantities, sizes, order, change and dynamism of single and complex systems it influences decision making, the chances of educational advancement and post-school and citizenship

opportunities; it is also a catalyst for national development (Moore, 2005; Anthony &Walshaw, 2009; Kajuru & Popoola, 2010; Awofala, 2011). Other scholars such as Agwagh (2001) and Sumbabi and Bassey (2013) posited that mathematics is an intellectually stimulating subject, a bed rock of science and technology and a link to the study of subjects like medicine, physics, chemistry and courses in engineering and earth sciences.

Globally students' underachievement in mathematics has been a worry to parents, scholars, researchers, science educators and governments (Makinde, 2012; Mbacho & Githua, 2013; Mensah, Okyere & Kuranchie, 2013). One area in mathematics where students have been found to perform poorly is geometry (WAEC, 2007 & 2009; Sumbabi & Bassey, 2013; Iji, Ogbole & Uka, 2014) Students are observed to be generally weak in geometry, dreaded this aspect of mathematics and only very few candidates attempt questions on geometry in standardized examinations such as WAEC and NECO SSSCE.

Geometry is a vibrant and exciting part of mathematics and a key to understanding our world through concrete experiences with geometric figures and relationship (Sumbabi & Bassey, 2013). It is also a science of space, which describes and measures figures. Further, geometry is a theory of ideas and methods by which we can construct and study idealized models of the physical world as well as of other real world phenomenon (Timku, 2004). Specifically, research reports indicated that many reasons account for students' poor achievement in geometry; among these are poor teaching approaches, lack of confidence in the subject and poor learning environment (WAEC, 2007; Basturk & Yavuz, 2010; Iji et al, 2014).

The teaching and learning of geometry have been observed to be difficult from both

the teachers' and student perspective. Ali, Bhagawati and Sarmah (2014) opined that the teaching of geometry is problematic because it requires knowledgeable and competent teachers. The authors also observed that due to teachers' poor mathematical background, many abstract concepts and formulas were introduced without paying much attention to the logic, reasoning and understanding. This leads to the difficulty experienced by students which is exhibited in failure to develop understanding geometric concepts, reasoning and problem solving skillswhich in turn affects their geometrical thinking.

Studies such as Chiason et al (2010), Adolphus (2011), Jones, Fujita and Kunimune (2012) and Ali et al (2014) seek the improvement of the teaching and learning of geometry in secondary schools because geometry is a key vehicle for the developing a learners' spatial thinking, visualization skills in mathematics, capability with deductive reasoning and proving. Learning geometry in secondary school highly depends on proper teaching learning methods.

2.4 Mathematics Teaching Methods

Learning mathematical concepts is an intellectual process that involves activities such as manipulating, visualizing, listening, reading, computing, writing, thinking, verbalizing, generalizing and symbolizing (Hellar & Mnyanyi, 2008). For learners to understand and explore all taught concepts of mathematics, the most effective approach, methods and techniques of teaching mathematics has to be utilized; this is certainly not an easy task. Pei-Shi (2012) opined that choosing the appropriate teaching and learning strategies is a complicated process that demands deep thinking on the part of the teacher and the ability to make balance between the available strategies in the light of the many interrelated variables.Students should gradually and appropriately be taught how to

analyze, synthesize, abstract, induce, deduce, generalize, specialize, and observe analogies, regardless of whether they will be seriously involved in mathematics at a later stage of their lives (Kurnik, 2008).

The search for methods that are effective and result oriented in mathematics is crucial and continuous. This is because poor methods and non-use of appropriate instructional material by the teacher leads to impaired understanding of taught mathematical concepts which is factor in the poor performance of students in our standardized examination (Makinde, 2012). The teaching of mathematics in our world today takes place in a various frameworks such as language frameworks, professional frameworks, methodology frameworks, scientific frameworks, pedagogical frameworks and psychological frameworks. These frameworks makes it possible for a learner to completely grasp the objective of instructions achievable.

A teaching strategy is in essence a general plan which includes all the parts of the teaching situation; namely: the objectives, teaching methods, teaching aids and evaluation strategies (Kurnik, 2008). Certain factors determine the choice of teaching methods utilized by the teacher. According to Hellar and Mnyanyi (2008), they include the:

1. topic to be taught
2. nature of set objectives to be met
3. teaching environment
4. learners background (age , previous knowledge and ability) and
5. type of instructional material that can be used.

The authors also gave guides lines for selecting from the many methods available for a teacher in the teaching of mathematical concepts as:

1. The method should be mathematically correct.
2. The method should have the meaning for the class
3. The method should meet the demands for a proper teaching procedure
4. The method should motivate both the teacher and learners

2.4.1 Some Mathematics Teaching Methods for Secondary Schools

Many methods have been developed for the teaching-learning process in mathematics.A few of them that are utilized in the teaching and learning of mathematics at the secondary school level are listed below. They include learning by:

1. play-way methods
2. project method
3. assignment system
4. questioning method
5. lecture-discussion method
6. cooperative and Collaborative learning
7. discovery method
8. inquiry method
9. problem solving
10. contextual approach
11. math-lab activity approach
12. practical activities

The use-ability of any of these methods depends on its appropriateness to a topic.

2.5 Conventional Method of Teaching Geometry in Secondary Schools

The teaching of geometry in Nigerian secondary schools follows the general conventional approach to teachingis considered an educational essentialism (Ihedioha, 2012; Achor, Imoko & Jimin, 2012). It is simply a chalk-talk approach in which students remain passive learners. Instruction is ill organized and rote learning is heavily emphasized. Mostly the results of students are not satisfactory due to the presence of this approach (Ihedioha, 2012).

According to Ali, Hukamdad, Akhter & Khan (2010), the conventional method of teaching mathematics is based upon lessons employing lecture/questioning method to teach concepts of selected topics and depends on the teacher's explanations, discussions and textbooks. This view is supported by Ihedioha (2012) who asserted that the conventional teaching is concerned with the teacher being the controller of the learning environment. He postulated that power and responsibility are held by the teacher who doubles as instructor and decision maker. The teacher sees the students as having 'knowledge holes' that needed to be filled with information and believes he/she causes learning to occur, and classroom discipline is based upon fear.

Students matched by age, and possibly also by ability and taught the same material characterize the classroom environment. The conventional or traditional education emphasizes direct instruction and lectures, seatwork and learning through listening and observation (Can Tech, 2013). They are the ordinary teaching methods used by teachers to deliver the contents of the syllabus to the learners (Macharia, Githua & Mboroki, 2009). Most conventional methods of teaching Mathematics are teacher-centered. The teacher

demonstrates and summarizes the main points and there is surface learning of concepts, principles and skills (Azel Online, 2012).

2.5.1 Conventional Teaching Method and Performance of Students in Geometry

The conventional teaching method has been indicted to contribute to the low potential and performance in learning geometry among students (Salleh -Abu1 & Abidin, 2013). This is because it is a teacher-centered approach that does not actively involve the students in the learning and problem-solving processes, as they are predominantly passive. This feature tends to inhibit development of students' intuition, imagination and creative abilities (Anyichie & Onyedike, 2012). This follows since the conventional teaching methods is deemed restricted to some degree and its classroom settings are teacher-centered where the teacher often talks to the students instead of encouraging them to interact, ask questions or make them understand the lesson thoroughly. The direction of communication is from teacher to student, which presents the teacher as the focal point of discussion and dispenser of knowledge (Ali *et al,* 2010).

Classes involve rote learning where students depend on memorization without having a complete understanding of the subject. Students have little opportunity to interact with their classmates or their teacher. Other feature of the conventional teaching method are long lectures and dictations, little interaction in the classroom which often leave students less attentive and less engaged. These and other disadvantages of the conventional teaching method makes students skip classes and miss lessons altogether. This accounts for performance of students in geometry and subsequent achievement in mathematics (Awofala & Nneji, 2011; Azel Online, 2012).

2.6 Cooperative Learning

Cooperative learningrefers to instructional methods in which the teachers organizes students into small groups, who then work together to help one another learn academic content (Johnson, Johnson & Smith, 2014). It is a mode of learning in which students of different levels of ability work together in small groups to achieve a purpose (Akinbobola, 2006).

Macpherson (2007:1) demonstrated when cooperative learning is desirable. She said:

> *Whenever problem solving is desired, whenever divergent thinking or creativity is desired, whenever quality of performance is expected, whenever the task is complex, when the learning goals are highly important, and when the social development of learners is one of the major instructional goals….*
> *When an instructor wishes to promote positive interaction among learners, a facilitative learning climate, a wide range of cognitive and affective outcomes, and positive relations between themselves and the learners …*

Cooperative learning is a process in which students create, analyze and apply concepts. Students learn life-long concepts that will be useful both inside and outside of school. They are required to work as a team, combining their knowledge and social skills. Students are often placed in heterogeneous groups and asked to accomplish a common goal. Each team member is assigned part of the content to be learnt and is not only responsible for their learning, but the other group members' learning as well. Students work until each group member successfully understands all concepts and then the assignment is completed.

According to Hsiung, Lin and Wang (2014), in the cooperative learning, students work together as a team to maximize the academic success of all the team members. The failure of even a single member can compromise the success of the entire team. Thus, to evaluate the functioning of the team reliably, it is necessary to consider both the performance of the individual team members and the interactions among them.

In the cooperative learning strategy small teams each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject matter. It is a learning environment that allows active participation of students in the learning process, makes it possible for the students to have control over their learning and this leads to improvement in students' learning and retention as to both the developmental and cognitive theoretical bases thereby prevailing classroom climate of cooperation (Johnson & Johnson, 2009). Each member of a team is responsible for not only learning what is taught but also for helping teammates learn, thus creating an atmosphere of achievement. Students work through the assignment until all group members successfully understand and complete it. Cooperative learning environment assumes that students seek information and understanding through active mental search with each group mirroring the make-up of the class in terms of ability, background and gender.

Felder and Brent (2007) see cooperative learning as students working in teams on an assignment or project under conditions in which certain criteria are satisfied, including that the team members be held individually accountable for the complete content of the assignment or project. It is a learner-centered approach that equips students with relevant cooperative skills that enable them to work and solve problems together with minimal efforts of the teacher(Aluko & Olorundare, 2011).

The cooperative learning environment is one that encourages teaching others and elaboration of ideas among students (Kagan & Kagan, 2009; Slavin, 2011). The consistent elaboration of learning concepts provides students who either receive the explanation or those who give the explanation with a deep understanding and a more complete retention of the concepts being learnt for a longer period of time (Chianson, Kurumeh & Obida, 2010). Consequently, students retain more knowledge when exposed to the cooperative learning where they offer more explanation and elaboration to colleagues (Tanel & Erol, 2008; Webb, 2008, Zakaria, Chin, & Daud, 2010).

Three types of cooperative learning have been identified. They are the formal, informal and group based cooperative learning (Johnson, 2008; Kagan, 2014).

2.6.1 Formal Cooperative Learning Group in Mathematics

In this approach, groups may last from several minutes to several class sessions to complete a specific task or assignment (such as doing a set of problems, completing a unit of work, writing a report, conducting an experiment, or reading and comprehending a story, play, chapter or book). The members are carefully chosen for heterogeneity to maximize learning and minimize 'group think'. It is also structured, facilitated and monitored by the educator over time. It is useful in achieving group-oriented tasks. Any course material or assignment can be adapted to these types of cooperative learning. Discussions can last to a lesson with groupings of 2 to 6 people. The examples of the formal cooperative learning strategy include: Jigsaw, assignment that involve group problem solving and decision making, laboratory (experimental) assignments and peer review work (such as editing assignments). According to Johnson and Johnson & Holubec (2008), the role of the teacher in the formal cooperative learning groups include:

1. ***Making pre-instructional decisions.*** Teachers formulate both academic and social skills objectives, decide on the size of groups, choose a method for assigning students to groups, decide which roles to assign group members, arrange the room, and arrange the material students need to complete the assignment. In these pre-instructional decisions, the social skills objectives specify the interpersonal and small group skills students are to learn. By assigning students roles, role interdependence is established. The way in which material are distributed can create resource interdependence. The arrangement of the room can create environmental interdependence and provide the teacher with easy access to observe each group, which increases individual accountability and provides data for group

processing.

2. ***Explaining the instructional task and cooperative structure.***Teachers explain the academic assignment to students, explain the criteria for success, structure positive interdependence, structure individual accountability, explain the behaviors (i.e., social skills) students are expected to use, and emphasize intergroup cooperation (this eliminates the possibility of competition among students and extends positive goal interdependence to the class as a whole). Teachers may also teach the concepts and strategies required to complete the assignment. By explaining the social skills emphasized in the lesson, teachers operationalize the social skill objectives of the lesson and the interaction patterns (such as oral rehearsal and jointly building conceptual frameworks) teachers wish to create.

3. ***Monitoring students' learning and intervening to provide assistance in completing the task successfully or using the targeted interpersonal and group skills effectively.***While conducting the lesson, teachers monitor each learning group and intervene when needed to improve task-work and teamwork. Monitoring the learning groups creates individual accountability; whenever a teacher observes a group, members tend to feel accountable to be constructive members. In addition, teachers collect specific data on promotive interaction, the use of targeted social skills, and the engagement in the desired interaction patterns. This data is used to intervene in groups and to guide group processing.
4. ***Assessing students' learning and helping students process how well their groups functioned.*** Teachers bring closure to the lesson, assess and evaluate the quality

and quantity of student achievement, ensure students carefully discuss how effectively they worked together (that is, process the effectiveness of their learning groups), have students make a plan for improvement, and have students celebrate the hard work of group members. The assessment of student achievement highlights individual and group accountability (that is, how well each student performed) and indicates whether the group achieved its goals (that is, focusing on positive goal interdependence). The group celebration is a form of reward interdependence. The feedback received during group processing is aimed at improving the use of social skills and is a form of individual accountability. Discussing the processes the group used to function, furthermore, emphasizes the continuous improvement of promotive interaction and the patterns of interaction need to maximize student learning and retention.

2.6.2 Informal Cooperative Learning Group in Mathematics

Johnson, Johnson & Holubec (2008) opined that the informal cooperative learning groups are temporary ad hoc groups that last from a few minutes to one class period. They are used to focus students' attention on the material to be learned, set a mood conducive to learning, help organize in advance the material to be covered in a class session, ensure that students cognitively process the material being taught, and provide closure to a class session. They are often organized so that students engage in focused discussions before and after a lecture and interspersing turn-to-your-partner discussions throughout a lecture. Informal cooperative learning groups help counter what is proclaimed as the main problem of lectures: The information passes from the notes of the professor to the notes of the student without passing through the mind of either one.

According to Kegan (2014), informal cooperative learning group incorporates group learning with passive teaching by drawing attention to material through small groups throughout the lesson or by discussion at the end of a lesson, and typically involves groups of two (e.g. turn-to-your-partner discussions). These groups are often temporary and can change from lesson to lesson (very much unlike formal learning where 2 students may be lab partners throughout the entire semester contributing to one another's knowledge of science). Discussions typically have four components that include formulating a response to questions asked by the educator, sharing responses to the questions asked with a partner, listening to a partner's responses to the same question, and creating a new well-developed answer. Johnson, Johnson & Holubec (2008) asserted that this type of learning enables the student to process, consolidate, and retain more information.

The teacher's role for using informal cooperative learning to keep students more actively engaged intellectually entails having focused discussions before and after the lesson (i.e., bookends) and interspersing pair discussions throughout the lesson. Consequently, two important aspects of using informal cooperative learning groups according to Johnson and Johnson (2002) are:

1. to make the task and the instructions explicit and precise and
2. to require the groups to produce a specific product (such as a written answer).

2.6.3 Base Group Cooperative Learning Group

Base Group Cooperative Learning are long-term, heterogeneous cooperative learning groups with stable membership whose primary responsibility is to provide each student the support, encouragement, and assistance he or she needs to make academic progress (INTIME, 2008; Johnson, 2008). Base groups personalize the work required and

the course learning experiences. These base groups stay the same during the entire course and longer if possible. The members of base groups should exchange phone numbers and information about schedules as they may wish to meet outside of class. When students have successes, insights, questions or concerns they wish to discuss; they can contact other members of their base group. Base groups typically manage the daily paperwork of the course through the use of group folders. Cooperative base groups are long-term, heterogeneous cooperative learning groups (lasting for at least one semester or year) with a stable membership, whose primary responsibility is to give each member the support, encouragement, and assistance he or she needs to progress academically and develop cognitively and socially in healthy ways.

According to Wong (2001), base group is effective for learning complex subject matter over the course or semester and establishes caring, supportive peer relationships, which in turn motivates and strengthens the student's commitment to the group's education while increasing self-esteem and self-worth. Base group approaches also make the students accountable to educating their peer group in the event that a member was absent for a lesson. This is effective both for individual learning, as well as social support. Johnson and Johnson (2002) postulated the following as the teacher's role in using cooperative base groups:

1. Forming heterogeneous groups of four (or three),
2. Scheduling a time when group members can regularly meet (such as beginning and end of each class session or the beginning and end of each week)
3. Creating specific agendas with concrete tasks that provide a routine for base groups to follow when they meet,

4. Ensuring the five basic elements of effective cooperative groups are implemented, and
5. Having students periodically process the effectiveness of their base groups.

The longer a cooperative group exists, the more caring their relationships will tend to be, the greater the social support they will provide for each other, the more committed they will be to each other's success, and the more influence members will have over each other. Permanent cooperative base groups provide the arena in which caring and committed relationships can be created that provide the social support needed to improve attendance, personalize the educational experience, increase achievement, and improve the quality of school life.

2.6.4 Essential Elements of Cooperative Learning

The essential elementcharacteristics of a cooperative group is that it must have clear positive interdependence, members must promote each other's learning and success face-to-face, hold each other personally and individually accountable to do his or her fair share of the work. In addition, it should appropriately use the interpersonal and small group skills needed for cooperative efforts to be successful, and process as a group how effectively members are working together. These five essential components must be present for small group learning to be truly cooperative (Slavin, 2011; Tran, 2014). Well-structured formal cooperative learning groups are differentiated from poorly structured ones on the basis of five essential elements. These essential elements should be carefully structured within all levels of cooperative efforts. The five essential elements and suggestions for structuring them are as follows:

1. **Positive Interdependence:** The heart of cooperative learning is positive interdependence. Students must believe that they are linked with others in a way that one cannot succeed unless the other members of the group succeed (and vice versa). Students are expected to work together to get a job done. In formal cooperative learning groups, positive interdependence may be structured by asking group members to agree on an answer for the group (group product--goal interdependence), making sure each member can explain the groups' answer (learning goal interdependence), and fulfilling assigned role responsibilities (role interdependence). Tran (2014) opined that positive independence needs to be constituted in cooperative learning groups to help students work and learn together. This is because it results in reciprocal interaction and promotes productivity and achievement among individuals. Other ways of structuring positive interdependence include having common rewards such as a shared grade (reward interdependence), shared resources (resource interdependence), or a division of labor (task interdependence).
2. **Promotive Interaction:** Once positive interdependence is established, students are expected to interact to help each other accomplish the task and promote each other's success. Students explain orally to each other how to solve problems, discuss with each other the nature of the concepts and strategies being learned, teach their knowledge to classmates, explain to each other the connections between present and past learning, and help, encourage, and support each other's efforts to learn. The students interact verbally with one another on learning tasks by exchanging opinions, explaining things and present their understanding (Johnson & Johnson,

2009; Tran, 2014) Silent students are uninvolved students who are not contributing to the learning of others or themselves.

3. **Individual Accountability:** The purpose of cooperative learning groups is to make each member a stronger individual in his or her own right. Students learn together so that they can subsequently perform better as individuals. To ensure that each member is strengthened, students are held individually accountable to do their share of the work. Individual accountability or responsibility means that students ask for assistance, do their best work, present their ideas, learn as much as possible, take their tasks seriously, help the group operate well, and take care of one another (Johnson & Johnson, 2009, Tran, 2014). This is facilitated by the positive interdependence which seeks to increase the individual accountability of group members for accomplishing shared work (Johnson & Johnson, 2005). The performance of each individual student is assessed and the results given back to the individual and perhaps to the group. The group needs to know who needs more assistance in completing the assignment, and group members need to know they cannot "hitch-hike" on the work of others. Common ways to structure individual accountability include giving an individual exam to each student, randomly calling on individual students to present their group's answer, and giving an individual oral exam while monitoring group work. In the example of a formal cooperative learning lesson that follows, individual accountability is structured by requiring each person to learn and teach a small portion of conceptual material to two or three classmates.
4. **Teamwork Skills:** Contributing to the success of a cooperative effort requires

teamwork skills. Students must have and use the needed leadership, decision-making, trust-building, communication, and conflict-management skills. These skills have to be taught just as purposefully and precisely as academic skills. Many students have never worked cooperatively in learning situations and, therefore, lack the needed teamwork skills for doing so effectively. Faculties often introduce and emphasize teamwork skills through assigning differentiated roles to each group member. For example, students learn about the challenge of documenting group work by serving as the task recorder, the importance of developing strategy and talking about how the group is working by serving as process recorder, providing direction to the group by serving as coordinator, and the difficulty of ensuring that everyone in the group understands and can explain by serving as the checker.

5. **Quality of Group Processing:** Professors need to ensure that members of each cooperative learning group discuss how well they are achieving their goals and maintaining effective working relationships. Groups need to describe what member actions are helpful and unhelpful and make decisions about what to continue or change. Such processing enables learning groups to focus on group maintenance, facilitates the learning of collaborative skills, ensures that members receive feedback on their participation, and reminds students to practice collaborative skills consistently. Some of the keys to successful processing are allowing sufficient time for it to take place, making it specific rather than vague, maintaining student involvement in processing, reminding students to use their teamwork skills during processing, and ensuring that clear expectations as to the purpose of processing have been communicated. A common procedure for group processing is to ask

each group to list at least three things the group did well and at least one thing that could be improved.

2.6.5 Benefits of Cooperative Learning Strategy

Kelly (2015) identified five benefits of cooperative learning strategies (Kelly, 2015). These are:

1. **Sharing a Common Goal:** According to him, students who work together as a team share a common goal and the success of the project depends on their combined efforts. The author asserted that the ability to work as a team towards a common goal is one of the main qualities that business leaders are looking for today in new hires. Consequently, cooperative learning activities help students practice working in teams and sharing a common goal allows students to learn to trust each other as they achieve more than would be possible on their own.

2. **Leadership Skills:** A very important benefit of cooperative learning identified by Slavin (1995) is the leadership skills. He postulated that in order for a group to truly succeed, individuals within the group need to show leadership abilities. Skills such as dividing out the tasks involved, providing support, and ensuring that individuals are meeting their goals are all leadership skills that can be taught and practiced through cooperative learning. He maintained that typical leaders will show themselves fairly quickly when assigned to a new group and leadership roles can be assigned within a group so that all individuals can practice leading the team.

3. **Communication Skills:** Here, Slavin said effective teamwork is all about good communication and a commitment to the product or activity. All members in the group need to practice communicating in a positive manner. These skills should be directly modelled by the teacher and reinforced throughout the activity. When students learn to talk with and actively listen to their teammates, the quality of their work soars and their task becomes result oriented.
4. **Conflict Management Skills:** Conflicts arise in all group settings. Sometimes these conflicts are minor and easily handled. Other times, though, they can rip a team apart if left unchecked. In most cases, you should allow your students to try and work out their issues before you step in and get involved. Keep an eye on the situation but see if they can come to a resolution on their own. If you do have to be involved, attempt to get all individuals of the team talking together and model effective conflict resolution for them.
5. **Decision Making Skills:** Many decisions will need attention while working in a cooperative environment. A good way to get students to start thinking as a team and make joint decisions is to have them come up with a team name. From there, the next decisions that need to be made are which students will perform what tasks. Additionally, even though students are working in a group, they will also have their own responsibilities. This will require them to make many decisions that could affect their entire team. As the teacher and facilitator, you should stress that if a particular decision will affect other members of the group then these need to be discussed together.

Kegan (2014) identified seventeen benefits of cooperative learning strategies that

are listed below:

1. **Academic Achievement:** He asserted that over 500 research studies supports the conclusion that cooperative learning leads to better academic achievement across all content areas, all grade levels, and among all types of students including special needs, high achieving, gifted, urban, rural, and all ethnic and racial groups. In terms of consistency of positive outcomes cooperative learning remains the strongest researched educational innovation ever with regard to producing achievement gains.
2. **Ethnic/Race Relations:** In classrooms without cooperative learning, there is increasing polarization along race lines over time but with cooperative learning, there is increasing cross-race friendships and mutual understanding.
3. **Self-Esteem:** Students in cooperative learning teams increase in feelings of social and academic esteem. These increased self-esteem enables the students do better academically and get accepted more by their peers.
4. **Empathy:** Students in cooperative learning teams gain in ability to take the role of the other and to understand and empathize with the point of view and feelings of others.
5. **Social Skills:** Cooperative learning increases a long list of social skills, including listening, taking turns, conflict resolution skills, leadership skills, and teamwork skills. Students coming from cooperative learning classrooms are more polite and considerate of others.
6. **Social Relations:** Students in cooperative learning classrooms feel accepted, liked, and cared for. This results in more mutual acceptance, caring among students and more friends.

7. **Class Climate:** Cooperative learning leads to increased liking for school, class, academic content, and the teacher. This makes for good learning opportunities.
8. **Responsibility:** Cooperative learning is associated with enhanced internal sense of control; students feel more like origins than pawns. They take more initiative and feel more responsible for the outcomes they receive. They feel more effective and their increased sense of efficacy is realistic because in cooperative learning they make more choices and have more input into what and how to study. What they do makes a difference.
9. **Diversity skills:** As a result of working in heterogeneous cooperative teams, students learn to understand and work with others who differ from themselves. These skills are essential for the 21st century as we are becoming more and more diverse.
10. **Higher Level Thinking Skills:** One of the main roads to higher level thinking is interaction with points of view different from one's own. Each of us carries his or her own set of information and way of interpreting that information. We tend to persist in our own way of thinking until we are challenged by interacting with someone with different information and/or a different way of interpreting the information. At that point we are pushed to higher level thinking and higher level synthesis. Interaction in heterogeneous teams, therefore, creates higher level thinking.
11. **Individual Accountability:** In a traditional classroom a student can dream, knowing they will not be held accountable if only they don't raise their hand to be called on. In a cooperative learning team there is not the luxury to slip through the

cracks. As we do a Round Robin, for example, each student in turn is held accountable to make a contribution.

12. **Equal Participation:** Volunteer participation leads to some always raising their hands, and others volunteering seldom or never. In cooperative learning structures, there is not the luxury to slip through the cracks, making participation more equal. For example, in a Timed Pair Share each student has equal time to share.
13. **Increased Participation:** If we call on students one at a time, even if we said nothing, and transitions were done in no time, in a class of 30 it would take 30 minutes to give each student one minute to share his or her point of view. In pairs the same amount of participation can be accomplished in two minutes! Overall, therefore students in cooperative learning are engaged a far higher percent of the time.
14. **Social Orientation:** In the traditional classroom students see each other as an obstacle. They know there are a limited number of top grades, and the success of another decreases their own probability of success. In cooperative learning students know the success of a teammate (mastering the material, for example) will increase the probability of their own success. They begin to see others as someone to work with rather someone to beat.
15. **Learning Orientation:** Too often students in traditional classrooms do their assignments for a grade. In cooperative learning they more often do their work for the joy of working with others, accomplishing a challenging goal, and being of worth to their teammates and classmates.
16. **Self-Knowledge and Self-Realization:** Students in interaction with others learn

about themselves. If I am dominant, shy, rude, or overly-helpful, I do not discover that until I interact with and get feedback from others. This self-knowledge leads to change and growth so I am more likely to realize my potential. Alone, in an important sense, we are stuck; in interaction we grow.

17. **Workplace Skills:** Students learn how to work in teams, preparing them for the interdependent team-based workplace of the 21st Century in which increased technology and complexity demands increasing use of interdependent teams.

The above benefits of cooperative learning are in line with the findings of Mbacho (2013) summarized as follows:

1. cooperative learning promotes thinking skills.
2. it involves the students actively in the learning process.
3. it improves classroom achievement
4. it models appropriate student problem solving techniques
5. cooperative learning benefits students socially

2.6.6 Methods of Cooperative Learning

Cooperative learning methods or techniques can be loosely categorized by the skill that each enhances. Although it is important to recognize that many cooperative learning exercises can be developed to fit within multiple categories (Barkley, Cross & Major, 2005). There are many methods of cooperative learning strategy. Johnson, Johnson & Stanne (2000) outlined the following as modern methods of cooperative learning:

2.6.7 Student Teams- Achievement Divisions (STAD)

This method involves assigning students to four-member learning teams that are mixed in performance level, gender and ethnicity. The teacher presents the lesson; the students then work together within their respective teams where they help team members to master the lesson. Next, the students take individual quizzes on what was learnt from the lesson. The students' quiz score is then compared to their own past averages. Based on this, points are awarded. These points are then summed-up to from team scores, which enable respective teams to earn awards (Seifert and Sutton, 2009).

2.6.8 Group Investigation

The group investigation is a method of cooperative learning where students from interest groups to plan and implement an investigation. The findings of such an investigation is presented to the class. Four important components involved in group investigation are: investigation, interaction, interpretation and intrinsic motivation. The teacher facilitates these components without giving his/her own ideas or rejecting the student' ideas.

The entire investigation is done in six steps outlined below:

1. Presentation of problem to the class
2. Group planning of investigation procedures
3. Implementation of plan
4. Planning of presentation to the class
5. Presentation of findings to the class
6. Evaluation by the class and teacher

Throughout the whole process, respective group representatives are obliged to report to the class of their progress.

2.6.9 Cooperative Integrated Reading and Composition (CIRC)

According Mbacho (2013), Cooperative Integrated Reading and Composition (CIRC) is a comprehensive program for teaching reading and writing in the upper elementary grades. The students are split into teams of four. Each team then engage in a series of activities with one another, including reading to one another, making predictions about how narrative stories will come out, summarizing stories to one another, writing responses to stories, and practicing spelling, decoding, and vocabulary. They also work together to master main ideas and other comprehension skills. During language arts periods, students engage in writing drafts, revising and editing one another's work, and preparing for publication of team books. Three studies of the CIRC program have found positive effects on students reading skills, including improved scores on standardized reading and language tests.

2.6.10 Cooperative Scripting

The cooperative scripting was developed on the premise that students generally find it helpful to get together with their classmates to discuss material they have read or heard in class. A formalization of this age-old practice has been researched by Slavin, (1991) and his colleagues. In is method, students work in pairs and take turns summarizing sections of the material for one another. While one student summarizes, the other listens and corrects any error or omissions. Then the two students switch roles, they continue in this manner until they have covered all the material to be learned. Cooperative scripting method has been found to consistently lead to better retention in students when compared to those who summarize on their own or who simply read the material.

2.6.11 Reciprocal Teaching

Paliscar & Brown (1984) developed reciprocal teaching in 1982. It is a cooperative technique that allows for student pairs to participate in a dialogue about text. Partners take turns reading and asking questions of each other, receiving immediate feedback. This strategy allows students to use important metacognitive techniques such as clarifying, questioning, predicting, and summarizing. It embraces the idea that students can effectively learn from each other.

2.6.12 Jigsaw Cooperative Learning Strategy

Jigsaw is a cooperative learning technique that was developed by Elliot Aronson and his colleagues in 1978. The jigsaw technique was created with the goals of reducing conflict, enhancing positive educational outcomes and to help students realize they are essential components of a whole and encourages cooperation in a learning environment. In order to create a more cooperative environment, Aronson and the teachers divided students into small groups that were diversified based on ability, ethnicity, and gender. This structure required students to take responsibility for their personal assignment in class and to work out any personal issues they had with one another. After eight weeks of using the jigsaw strategy, Aronson reported that students expressed less prejudice and negative stereotyping, displayed more self-confidence, and showed more positive attitudes to school than did their peers in traditional classes. Academically, students who participated in the jigsaw learning technique showed greater academic improvement than their peers.

In science education, the Jigsaw method and its variants are reported to be used in classes more often than other collaborative learning methods, especially in biology, chemistry, physics, Mathematics and the Earth sciences. This is because the Jigsaw method is considered to enhance cooperative learning by making each student focus on a particular

topic (Jansoon, Smoosook & Coll (2008). Jigsaw is a cooperative learning strategy in which everyone becomes an expert and shares learning so that eventually all group members know the content.

There are currently six types of Jigsaw cooperative learning strategies available for teachers to use in the classroom (Jansoon *et al*, 2008). They are: Jigsaw I, Jigsaw II, Jigsaw III, Jigsaw IV, Reversed Jigsaw and the Subject Jigsaw.

2.6.13 Jigsaw in 10 Easy Steps

Generally, the Jigsaw is implemented by the following procedure:

1. Divide students into 5- or 6-person jigsaw groups. The groups should be diverse in terms of gender, ethnicity, race, and ability.
2. Appoint one student from each group as the leader. Initially, this person should be the most mature student in the group.
3. Divide the day's lesson into 5-6 segments.
4. Assign each student to learn one segment, making sure students have direct access only to their own segment.
5. Give students time to read over their segment at least twice and become familiar with it. There is no need for them to memorize it.
6. Form temporary "expert groups" by having one student from each jigsaw group join other students assigned to the same segment. Give students in these expert groups time to discuss the main points of their segment and to rehearse the presentations they will make to their jigsaw group.
7. Bring the students back into their jigsaw groups.

8. Ask each student to present her or his segment to the group. Encourage others in the group to ask questions for clarification.
9. Float from group to group, observing the process. If any group is having trouble (e.g., a member is dominating or disruptive), make an appropriate intervention. Eventually, it's best for the group leader to handle this task. Leaders can be trained by whispering an instruction on how to intervene, until the leader gets the hang of it.
10. At the end of the session, give a quiz on the material so that students quickly come to realize that these sessions are not just fun and games but really count.

2.6.14 Jigsaw I

This is the original work of Aronson and associates (Aronson, 2008). Here, students are members of two groups: home group and expert group. The students work in a 'home group' which is heterogeneous in nature. They each are assigned to read an expert sheet, and then those who have the same expert sheet move from the home group to a separate expert group in which they then discuss their topic in detail. Once the discussion in the new group is complete, they return to their home group, and teach all their home group members about the topic that they are now expert in. Once back in their home group, each student is accountable for teaching his or her assigned topic (Jansoon *et al*, 2008; Maden, 2011). Finally, the groups are assessed, and individual grades are given.

2.6.15 Jigsaw II

Jigsaw II, a modification of the Jigsaw I was developed by Robert Slavin's in 1987. In Jigsaw II, members of the home group are assigned the same material, but focus on separate portions of the material. Each member must become an "expert" on his or her

assigned portion and teach the other members of the home group (Maden, 2011). This revised version of the method involves using computed team scores such as the Student Teams-Achievement Division (STAD) method. Also, Jigsaw II has two substantial changes: all students in the team read all the lessons, and the scores of students are combined to contribute to an overall team score. This method has been used for subjects in the social sciences, and in science particularly when the learning goals focus on concepts rather than skills.

2.6.16 Jigsaw III

Jigsaw III was created by Stahl (1994). However, Gonzalez and Guerrero (1983) modified Jigsaw II to increase the interaction between students. It has an addition of a cooperative test review process. This cooperative test review involves reconvening the home group and reviewing the process.

2.6.17 Reverse Jigsaw

The Reversed Jigsaw was created by Timothy Hedeen (2003). It differs from the original Jigsaw during the teaching portion of the activity. In the Reverse Jigsaw technique, students in the expert groups teach the whole class rather than return to their home groups to teach the content (Hedeen, 2003).

2.6.18 Subject Jigsaw

Doymus (2007) developed the Subject Jigsaw. It is also used in group-based learning in which students need to cooperate with their peers in order to achieve personal goals. Each student is like a piece of puzzle who needs to understand and learn the subject completely (Fini, Zainalipour & Jamri, 2012).

2.6.19 Jigsaw IV

Jigsaw IV, developed by Holliday (2002), includes three important new features: an introduction, quizzes, and re-teaching after individual assessment. In order to stimulate student interest in the lesson, the teacher first introduces the lesson by means of lectures, presentation of literature, questioning, proposing problems, or perhaps showing a movie in a 'plenary' class session. Students are then assigned to a heterogeneous group – the home group – and all students are assigned topics to read. Here each student discusses the expert sheet that is based on a list of all topics. Again, the students with the same expert sheet move to their expert group to discuss their topic. In order to check accuracy and understanding of students in the expert group, they are assessed by means of a quiz – this being based on the expert sheet. They return to their home group, teach all their group members and take quizzes all based on the original material. The teacher reviews and clarifies any concepts which it appears the students did not understand. The students take individual quizzes, and scores are combined to produce an overall team score. Finally, the teacher re-teaches any material which was misunderstood after the individual assessment process (Jansoon *et al*, 2008). These features make the Jigsaw IV better than the others (Jigsaw I, II and III). This is reflected in Table 2.1.

Table 2.1: Comparison of Jigsaw, Jigsaw II, Jigsaw III, and Jigsaw IV

	Jigsaw	**Jigsaw II**	**Jigsaw III**	**Jigsaw IV**
1				Introduction
2	Expert sheet assigned to expert group	Same as Jigsaw I	Same as Jigsaw I	Same as Jigsaw I
3	Member answer expert questions	Same as Jigsaw I	Same as Jigsaw I	Same as Jigsaw I
4		-	-	Quiz

	-			
5	Member return to home group and information	Same as Jigsaw I	Same as Jigsaw I	Same as Jigsaw I
6	-	-	-	Quiz
7	-	-	Review Process	Same as Jigsaw III
8		Individual Assessment and grade	Same as Jigsaw II	Same as Jigsaw II
9	-	-	-	Re-teaching

Source: Jansoon *et al*, 2008

2.6.20 Jigsaw IV Procedure

There are nine (9) steps in the Jigsaw IV procedure as postulated by Holliday (2002). They are as follows:

1. Introduction to the lesson
2. Expert sheets assigned to expert group
3. Groups answer expert questions prior to returning to home group
4. Quiz on material in the expert group groups checking for accuracy
5. Students return to home groups sharing information with teammates
6. Quiz on material shared checking for accuracy
7. Review process. Whole group by Jeopardy, Quiz Bowl etc.
8. Individual assessment and grading
9. Re-teach any material missed on assessment as needed.

2.6.21 Jigsaw in the classroom

Aronson recommends using a 10-step approach to implementing the jigsaw technique into classroom practice.First, teachers create small heterogeneous groups with students representing multiple ability levels. Then, the teacher appoints a group leader to be in charge of the group's tasks. Next the teacher assigns the group several tasks, depending on the number of students in each group. Each student is in charge of completing a separate task. The teacher allots a certain amount of time for students to complete their tasks or become familiar with material. Then, students from different groups who have the same tasks work together temporarily to become "experts" on their topic and fill in any gaps in their information. Original group members come back together and each member presents his/her own information and provides an opportunity for rest of group to ask questions. While students are teaching each other about the topic, the teacher moves around the room monitoring progress and answering any questions that students have about the topics. Finally, students are assessed on the material they have all learned through their cooperative learning.

Research suggests that jigsaw is used across all grade levels from K-16 to graduate and professional courses in various content areas. Since the creation of jigsaw, several modifications have been introduced to account for concerns of both teachers and students who have participated in the classroom technique.

In Jigsaw II, students carry out research in specific topics as opposed to parts of one larger reading. This variation of the original technique also requires that students complete "expert sheets" that provide notes for introducing the topic back to base group and are given individual assessments as opposed to a group evaluation (Holliday, 2002). Jigsaw III allows for a review process prior to assessment. Jigsaw IV has several additional features:

teacher introduction of material; expert group quizzes; review process prior to individual assessment; and re-teaching of any material that wasn't adequately explored in the collaborative group work (Holliday, 2002).

2.7 The Concept of Interest and Academic Performance in Mathematics

The term 'Interest' has been variously defined as a kind of consciousness accompanying and stimulating attention, a feeling pleasant or painful directing attention - the pleasurable or painful aspect of a process of attention and as identical with attention itself (Knight, 2012). It is a psychological state characterized by a high level of attention, intensiveeffort, and prolonged engagement with an activity and accompanied by feelings of pleasure and a sense of achievement which is assumed to be derived from learner – content interaction (Hidi& Renninger, 2006). This means that interest is a function of an individual's attention with respected to an activity.

According to Silvia (2006), interest is a feeling or emotion that causes attention to focus on an object, event, or process. In contemporary psychology of interest, the term is used as a general concept that may encompass other more specific psychological terms, such as 'curiosity' and to a much lesser degree 'surprise'. The term interest is used also to indicate a permanent mental disposition. Apart from being a function of attention, interest is an emotional disposition. It is also seen as a drive and learners develop competence and efficiency in areas or subjects they have interest (Ngwoke, 2005; Miner & Lauri, 2008).

The role of interest in education is crucial and important. John Dewey, one of the renowned psychologist of our time opined that

> Interest represents the moving force of objects – whether perceived or presented in imagination – in any experience having a purpose. In concrete, the value of recognizing the dynamic place of interest in education development is that it leads to considering children in their specific capabilities, needs and preferences. (p125).

Interest refers to the stored knowledge, value and feelings with which students' re-engage mathematics; it has been found to positively impact attention, learning strategies, and goal setting and in its most developed form is characterized by questioning and seeking answers to questions — behaviors suggesting that reengagement is perceived to be "sensible, useful, and worthwhile (Hidi & Renninger, 2006; Ray & Renninger, 2007). Consequently, the level of a person's interest has repeatedly been found to be a powerful influence on learning. This influence is noted in an individual's attention, goals and level of learning (Hidi & Renninger, 2006).

In educational research, interest has been conceptualized as individual and situational. Interest theorists typically differentiate between two main kinds of interest: individual and situational interest. Theoretical models of individual interest identify situational factors as critical in the development of individual interest (Hidi & Renninger, 2006).

2.7.1 Individual Interest

Individual or personal interest has a dispositional quality, residing in person across situations and it is relatively stable across situations. This is interest built on stored knowledge about a class of subjects or ideas which leads to a desire to be involved in activities related to such; It is the interest that students bring to some environment or context and exhibited as an inner drive to seek out opportunities to learn more about a

specific topic (Prendergast, 2011). Hiddi and Renninger (2006) conceptualize individual interest as an individual's long-term, deepening personal connection to a domain. In this view, interest deepens as individuals acquire knowledge of a domain and come to value it, which in turn inspires curiosity and further exploration of the domain.

According to Prendergast (2011), 'individual interest' is a relatively enduring predisposition that develops over time and is associated with increased knowledge, value, and positive feelings. A learner's individual interests energizes and motivates their thoughts and actions in a goal-directed way. An interested person can therefore formulate curiosity questions, and attenuate negative feelings, such as frustration and anxiety (Hidi & Renninger, 2006).

2.7.2 Situational Interest

Linnenbrink-Garcia, Durik, Conley, Barron, Tauer, Karabenick & Harackiewicz (2010) asserted that situational interest emerges in response to features in the environment. Situational interest (SI) consists of both an attentional and affective reaction to the situation, which can be differentiated into two forms-triggered-SI and maintained-SI (Linnenbrink-Garcia *et al*, 2010). Triggered-SI involves heightening the affective experiences individuals associate with the environment. Triggered-SI is similar to conceptualization of "catch" in that both constructs involve arousing or grabbing an individual's interest; however, triggered-SI refers specifically to initiating interest (Hidi & Renninger, 2006). On the other hand, the maintained-SI, which is also called "hold," is a deeper form of situational interest in which individuals begin to forge a meaningful connection with the content of the material and realize its deeper significance. Although situational interest can refer to interest that emerges in a variety of settings, we focus

specifically on situational interest that emerges in educational settings. Within these settings, features that promote triggered-SI influence students' ongoing affective experiences so that students actively attend to the material (Linnenbrink –Garcia *et al*, 2010).

2.7.3 The Role of Interest in the Learning of Geometry

There is no contest as to the importance of interest in the learning of geometry as branch of mathematics. Studies such as Imoko & Agwagah, 2006; Del Favero, Boscolo, Vidotto, & Vicentini (2007), Prendergast (2011) and lazarides and Ittel (2012), asserted that interest has a powerful influence on academic performance and they demonstrated the function of interest in fostering, remembering and understanding material, and stimulating students' positive attitude towards a topic. Interest has a profound effect on students' recollection and retrieval processes, their acquisition of knowledge, and their effort expenditure. Consequently, an interested individual is more likely to develop high competency and to receive positive feedback from others (Prendergast, 2011). Being interested may also serve as protection (Hidi & Renninger, 2006).

It follows that when students show interest in mathematics they will develop high competence for the subject which is a key to early stages of learning, as well as to differentiate between expert and moderately skilled learners. When interested in a topic or domain, students are more likely to use higher-order learning, thus improving their knowledge. This is most needed in problem solving which is the heart of mathematics. Interest in mathematics as a subject is very important and has crucial implication for its study. Lack of interest in mathematics has direct implication students' motivation to learn

skills needed for accomplishing everyday tasks and for involvement in science, technology, engineering, and mathematics (STEM) disciplines (Urerz, Dekkers, Beguin, 2004; Amelink, 2012).

Literature have demonstrated that interest has a powerful influence on academic performance proving to be the energizing function of fostering, remembering and understanding material, and stimulating students' positive attitude towards the subject such as mathematics (Del Favero *et al*, 2007; Prendergast, 2011). Research has found interest to develop in individual's high competency and affect positively students' recollection and retrieval processes; their acquisition of knowledge and serves as protection against the negative effects of failure (Hiddi & Renninger, 2006; Prendergast, 2011). Furthermore, Del Favero *et al* (2007) postulated that interest influences learning by inducing strong attention to learning material and increasing persistence in tasks.

According to Dweck (2007) interest influences mathematical ability and achievement; this view is supported by Urerz et al (2004) and Sumbabi and Bassey (2013) who opined that low interest in mathematics produces a corresponding low achievement which in turn leads to an individual's less interest in taking challenging curricular prior to enrolling for tertiary education and less interest in pursuing a career in Science Technology Engineering and Mathematics (STEM) discipline (Usher, 2009; Amelink, 2012).

Many factors have been implicated for students' low and lack of interest in mathematics. These include: parental, teacher, school, social and cultural related factors in and outside the educational settings (Amelink, 2012). Even though interest on the overall is low across gender for mathematics, female students have been found to be exhibit markedly lower interest for the subject (Wells, Sanchez & Attridge, 2009; Frenzel, Goetz,

Pekrun & Watt, 2010; Amelik, 2012) which affects their ambition for pursuing a career in STEM related degrees. However, Freeman (2004) disagrees with the foregone report stating that this may not be evident as female enroll in mathematics based courses throughout middle and high school (in Nigeria JSS and SSS) at the same rate as their male counterpart and perform similarly in standardized tests.

2.8 Overview of Related Studies

Kolawole (2008) investigated the effects of competitive and CLS on academic performance of Nigerian students in mathematics. The study utilized the quasi-experimental research design involving a sample of 400 senior secondary year two (SSII) mathematics students which comprised 240 boys and 160 girls drawn at random from four states in South West Nigeria. Quasi experimental design was adopted for the study and two instruments were used namely Mathematics Pre-test Achievement Test (MPTAT) and Post-Test Achievement Test (PAT) to collect data which were subjected to Z-test analysis at 0.05 level of significance. The findings revealed that cooperative learning strategy is more effective than competitive learning strategy and that boys performed significantly better than girls in both learning strategies. The author recommends CLS for Nigerian secondary schools. This study was not targeted at a particular area of mathematics where students are found to have difficulty. The present study is interested in geometry which students have been found to dread.

Jansoon, Somsook and Coll (2008) investigated Thailand undergraduate chemistry practical learning experiences using Jigsaw IV CLS. The hands-on experimental design based on Jigsaw IV was used on a sample of 244 first-year students. The research instruments used are the self-completion questionnaires and classroom observations. The

study revealed that exposure of students to the Jigsaw IV CLS produced higher test scores and interest in them. The authors suggested that the Jigsaw IV CLS which is learner-centered be used in teaching science subjects like chemistry, biology, physics, mathematics and earth science related fields. The study reviewed lacks proper research design and data collection instrument. It is just a try out and not a full research. The present study was a complete study with gender in perspective and interest of students for geometry as a variable. However, the use of Jigsaw IV CLS is common to the present study too.

A similar study titled the effect of Jigsaw IV CLS on the academic achievement of course of language teaching methods and techniques was investigated by Maden (2010). The pretest posttest quasi-experimental research design with 62 students as sample participated in the study. The sample was split into two groups; experimental (n = 32) taught by the Jigsaw IV CLS and control (n = 30) taught using the conventional teaching method. Data were collected by means of Language Teaching Methods and Techniques Achievement Test (LTMTAT) and the Student Opinion Form (SOF). The statistical mean, standard deviation and t-test were used to analyze the data. The students in the experimental group were found to have higher scores and better retention than students in the control group. It was concluded that the Jigsaw IV CLS is very efficient, produces positive attitude among students and its application in other subjects like mathematics was encouraged. The study was well implemented and served as a model for the present one. However, it only had performance as the only variable which was tested. The present research had interest as well.

In another account, Gubbad (2010), investigated the effect of CLS on the academic achievement and retention of the mathematics concepts learning of sixth grade students at

primary school in Holy Makkah in Saudi Arabia. The research design used was the quasi-experimental involving two groups of students in experimental and control groups. The study sampled 59 students divided into two groups: and the experimental group (30 students) who were exposed to the CLS and the control group (29 students) taught the same mathematics concept using the traditional method. The Mathematics Achievement Test (MAT) was used to collect data for the study. Frequencies, percentages, means, standard deviations and t-test were used for the analysis of data. The results of the study showed that there is a statistical significance difference at the level (0.05) between the means score performance in favour of the experimental group on achievement and retention. The study recommended that teachers should practice and use CLS in teaching all other subjects and encourage similar studies on a larger sample than that used in the study be conducted elsewhere. The study was good except that the sample utilized was inadequate and the area of mathematics explored was not specific. Moreover, the study did not explored performance with regard to gender. The present study better sample participation, gender in perspective and it is interested in comparing the interest level of students when exposed to the J4CLS.

Chianson, Kurumeh and Obida (2011) sought the effects of CLS on student's retention in circle geometry in secondary schools in Benue State Nigeria. The study compared CLS with the conventional learning method (CLM) to ascertain the academic achievement and retention of students in mathematics (circle geometry). The quasi experimental research design involving a pretest, posttest and post -posttest was used. The sample to the study was purposively drawn and comprised 358 Senior Secondary year two (SSII) students grouped into experimental group (n = 174) taught by the CLS and control

group (n = 184) taught by CLM. The instrument used in the study are the Pre-Geometry Achievement Test (Pre-GAT), Post Geometry Achievement Test (Post-GAT) and Retention Geometry Achievement Test (Ret-GAT). The finding of the study revealed that CLS produces better achievement and retention in students than CLM. The authors suggested that further research be conducted in other taught concepts by the CLS. This study had a specific area of geometry to compare. Although the sample was adequate, the sampling technique was purposively drawn which make the result obtained a bit faulty. In the present study the sampling followed the simple random method. Furthermore, a better CLS was compared to the conventional teaching method.

Daneshamooz et al (2012), carried out a study titled on the effect of three types of learning methods:Cooperative Learning Strategy (CLS), e-learning and traditional method of learning mathematics. The participant were university students in Iran. The Random multistage stratified sampling design was used on a sample of 126 students grouped into the three learning strategies (each n = 42). Three instruments namely: Mathematics Achievement Test (MAT), Digit Span Backwards Test (DBT) and Mathematics Anxiety Rating Scale (MARS) were utilized and data collected were analyzed by the Pearson Product Moment Correlation (PPMC) and the Analysis of Covariance (ANCOVA). The study revealed that students in the CLS group had higher test scores than their counterpart in the other groups. The authors concluded that CLS brings about better performance in mathematics among students. This study is a comparison of three pedagogical approaches with adequate sample and good sampling technique. However, it only centered on performance of the three groups. The testing of psychological variable such as interest, attitude etc would have made it a better. The current study compared performance and

interest across two methods of teaching. These variables are considered part of the predictors of good performance in mathematics.

In another account, Fini, Zainlipour and Jamri (2012) investigated the effect of CLS with focus on Jigsaw II technique on the academic achievement of students in mathematics. The authors utilized the semi-experimental research design involving pretest and posttest. A sample of 153 students were drawn by the multi-stage technique. The study revealed that Jigsaw II CLS has significant effect on students' academic achievement evidenced by the higher mean scores of students as compared to the other students taught same concepts by the traditional method. The authors concluded that Jigsaw CLS enhances students' academic achievement in mathematics. This study utilized the Jigsaw II CLS but the present study used the J4CLS. The researchers in the study under review did not consider the issue of gender which is a very important variable in educational research. The current study has gender in focus and geometry as a specific area of mathematics as a problem.

Duff (2012) compared CLS and Direct Instruction (DI). The author used these two instructional models to determine their impact on the mean score of students learning in a middles school mathematics classroom. The study utilized the survey design with two questionnaires for the CLS and DI respectively. The study revealed that CLS brings about better higher test scores, interest and participation in mathematics when compared to the DI. Hence the CLS was recommended for mathematics instruction. This study used a weak research design. The authors should have considered using the quasi-experimental design and a proper research instrument such as a mathematics achievement test rather than using questionnaire. With the survey design, correct gender achievement cannot be ascertained.

The present study has considered all the items mentioned and included the a psychological variable of interest for comparison between the experimental and control groups.

Consequently, Mbacho and Githua (2013) sought the effect of Jigsaw CLS on students' achievement in secondary school mathematics in secondary schools in Kenya. The Solomon four non-equivalent control groups research design was used on a sample of 160 students from mixed-sex secondary schools formed four groups split in to two experimental (n = 40 and n = 42) and two control (n = 38 and n = 40) respectively. The experimental group was exposed to Jigsaw CLS while the control group was taught by the conventional method. Data was collected via the Mathematics Achievement Test (MAT) and analyzed using the t-test and ANOVA. Students in the experimental group were found to perform better than those in the control group. Also, there was no significant gender difference in achievement when students were exposed to Jigsaw CLS. The authors asserted that the Jigsaw CLS results in better performance and interest in mathematics among students and suggested that teacher training colleges and universities emphasize the use of Jigsaw CLS as an effective method of teaching mathematics. This study was well done. The research design, sample, instrument and statistical tool utilized were adequate. However, the issue of gender was left out. Also, there are other Jigsaw methods such as J4CLS which are better result oriented that the researcher can use. The study at hand will fill the gaps of gender and a psychological variable of interest with regard to geometry.

Gambari and Olumorin (2013) on the other hand investigated the effectiveness of video-based CLS on high, medium and low achievers in mathematics (geometry). The study was conducted in Nigeria on 120 senior secondary school studentsgrouped into cooperative, competitive, individualized and conventional teaching strategies. The pretest

posttest research design was utilized and two research instruments namely: Video Instructional Package (VIP) and the Geometry Achievement Test (GAT) was used to collect data. The analysis of variance (ANOVA) and the Scheffe's test were used in the analysis of data. The study revealed a significant difference in the performance of students in favour of the CLS group and concludes that CLS be adopted by teachers of mathematics to improve students' performance to bridge the gap among high, medium and low achievers. The study under review is laudable in its comparison of low, medium and high achievers in geometry with respect to Video-based CLS. However, the use of such methods may be limited due to high cost of set-up. The present study considered a more realistic method to the teaching and learning of geometry. It also compared performance and interest of students in geometry with regard to geometry.

Tran (2014) carried out a study on CLS on the academic achievement and knowledge retention among students. This study used a "convenient sample" (Creswell, 2009) of 110primary education students from two intact classes in Faculty of Education at An Giang University. One class (n_1 = 55) acted as the experimental group, and another class (n_2 = 55) acted as the control group. The pretest-posttest non-equivalent comparison-group design and a sample of 110 first-year primary education students split into two groups: experimental (n = 55) and control (n = 55) participated and were taught by the CLS and lecture method respectively. The study revealed that the experimental group had higher scores on achievement and knowledge retention posttest than the control group. The authors concluded that CLS stimulates cognitive activities, promotes higher level of achievement and knowledge retention. CLS was recommended as an alternative instructional pedagogy.The author suggested that the role of CLS in the integration

between branches of mathematics be investigated. This study considered CLS in performance and retention. The research design and sample were appropriate although the study was carried out in primary schools. The results obtained was realistic. Gender performance was not compared. The current study is interested not only in gender performance but also in interest of students for geometry.

A recent study Mari and Gumel (2015), investigated the effect of CLS on students' self-efficacy and achievement in chemistry at the college of education level in Nigeria. Two groups of students which comprised of 200 level chemistry students of the 7 State Colleges of Education in the North-west geopolitical region were randomly selected for the study as experimental group (exposed to the CLS, n= 96) and control group (taught by the traditional method, n= 84). The Pretest-posttest experimental control group research design was utilized with three instruments General Self-Efficacy Subscale (GSES), Chemistry Achievement Test (CAT) and Test of Logical Thinking (TOLT). Data was analyzed using the t-test statistic at $P \leq 0.05$ level of significance. Result obtained revealed that the use of CLS has significant effect on the academic achievement of formal 'reasoners' more than that of the concrete 'reasoners'. Students with formal reasoning were more enhanced in their academic achievement than those with concrete reasoning when exposed to the cooperative learning strategy.

2.9 Implication of Literature Reviewed to the Present Study

The review of relevant literatures revealed that the traditional method of teaching geometry has not produced the desired result hence the need for a result oriented like the cooperative learning strategy (CLS) which has been found to be a result oriented pedagogical approach where students are actively involved. This is evident in the

consistency of findings among authors in different countries of the world across various levels of educational institutions. For instance, the study by Gubbad (2010) was in primary school but the result was consistent with that of Mbacho and Githua (2013), Janson *et al* (2008), Gambari and Olumorin (2013) and Arisoy and Tarim (2013) which were studies on CLS taken either in a secondary school or in a university. In all, CLS was found to produce higher test scores among students. These studies concentrated more on the performances of students in the groups. The present study considered the effect of J4CLS on gender.

The CLS was found to produces higher test scores even when compared with other teaching methods. In studies such as Kolawole (2008), Chianson et al (2011), Daneshamooz et al (2012), Duff (2012) and Gambari and Olumorin (2013) the effectiveness of the CLS on students' achievement in mathematics was clearly demonstrated among students when compared to other methods such as traditional or conventional methods, competitive, e-learning, direct instruction and others.

The review of related studies viewed the conventional teaching method as ineffective. Hence, the need to try out other more practical oriented strategies (that encourages students to learning together) such as Jigsaw IV CLS which was found to enhance students' achievement and interest in mathematics. The contributions of Jansoon et al (2008), Maden (2010), Fini et al (2012) and Mbacho and Githua (2013) showed that the Jigsaw CLS is reliable and efficient in the teaching of some mathematics concepts. The present study seeks the efficacy of the Jigsaw IV CLS on student's achievement in geometry. These studies will serve as a guide.

Furthermore, studies reviewed also revealed that the CLS has the potential to enhance students' retention and interest in mathematics. The findings of Gubbad (2010),

Chianson et al (2011), Duff (2012) and Tran (2014) confirmed that CLS simulates cognitive activities, promotes higher achievement, retention and interest in mathematics in students. In one case, a significant difference was found in test score in favour of boys over girls (Kolawole, 2008).

The present study considered this gap in gender as it relates to interest and performance in geometry among secondary school students. Also, most of the studies reviewed used the Jigsaw I and II hence, the use of Jigsaw IV in the present study is unique.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presented the outline of procedures for the study, the effects of Jigsaw IV cooperative learning strategy on interest and academic performanceof secondary school students in geometry in Kaduna State. The aim of this study was to investigate the effects of Jigsaw IV cooperative learning strategy on the academic performance of students in geometry. It also determined the interest of students in geometry when exposed to the Jigsaw IV cooperative learning strategy. In each case the issue of gender was also explored. The methodology was discussed under the following sub-headings:

3.2. Research Design

3.3 Population of the Study

3.4 Sample and Sampling Technique

3.5 Instrumentation

3.6 Validation of the Instruments

3.7 Pilot Testing

3.8 Reliability of the Instruments

3.9 Administration of the Instruments

3.10 Data Collection Procedure

3.11 Procedure for Data Analysis

3.2 Research Design

The research design adopted for this study was the quasi-experimental research design, whichcomprisedof two-groups, one experimental (**EG**) and the other control (**CG**). Both groups were pretested ($\mathbf{O_{1_I}^P}$) each rformance (**P**) and interest (**I**) before the administration of treatment. The essence of which was to ensure uniformity and equivalence in performance and interest level at entry point. The treatment ($\mathbf{X_1}$- Jigsaw IV cooperative learning) was administered to students in the experimental group only; while students in the control group were taught using the lecture method which implies no treatment ($\mathbf{X_O}$). A Posttest ($\mathbf{O_{2_I^P}}$) was administered after treatment to both groups of students to determine their performance and interest level. Figure3.1 shows an illustration of the design.

EG $\rightarrow \boldsymbol{O_{1_I^P}} \rightarrow X_1 \rightarrow \boldsymbol{O_{2_I^P}}$

CG $\rightarrow \boldsymbol{O_{1_I^P}} \rightarrow X_0 \rightarrow \boldsymbol{O_{2_I^P}}$

Fig. 3.1: Research Design

Where

EG = Experimental Group
CG = Control Group
$\mathbf{X_1}$ **=**Treatment (Cooperative learning – Jigsaw IV)
$\mathbf{X_O}$ **=** No Treatment (Lecture method)
$\mathbf{O_1}$ **=** Pretest
$\mathbf{O_2}$ **=** Posttest
P = Performance
I = Interest

3.3 Population of the Study

The population of the study comprisedof all senior secondary school year two (SS II) students of the public schools in Zaria Educational Zone, Kaduna State. This was made

up of nineteen (19) senior secondary schools with a total enrollment of four thousand, six hundred and twenty-four (4624) students. The zone has nine (9) co-educational schools, five (5) boy's schools and five (5) girl's schools located in various settlements in two Local Government Areasnamely: Zaria and Sabon-Gari LGAs which have the characteristic elements that are of interest to the researcher such as student population; co-education and geographical spread. Table 3.1 presents the population of the study. It showed that the study area comprised male and female students in single sex and mixed schools in various school location with their respective enrollment with respect to gender.

Table 3.1: Population of the Study

S/No	School	Location	Sex		Total	School Type
			Male	Female		
1	Barewa College Zaria	Zaria	416	-	416	Boys
2	GSS Yakasai		45	5	50	Co-education
3	GSS T/Saibu (SNR)	T/Saibu	99	18	117	Co-education
4	GSS Aminu (SNR)	S/ Gari	241	51	292	Co-education
5	GSS Dinya	Dinya	43	2	45	Co-education
6	GSS Dakaci	Dakachi	66	37	103	Co-education
7	GSS T/ Jukun	T/Jukun	133	217	350	Co-education
8	GGSS Pada (SNR)	Zaria City	-	150	150	Girls
9	GGSS D/Bauchi (SNR)	S/ Gari	-	500	500	Girls
10	S.I.A.S.S.S K/Karau	K/Karau	115	135	250	Co-education
11	GGSS Chindit (SNR)	S/ Gari	-	185	185	Single –girls
12	GSS Chindit (SNR)	S/ Gari	452	-	452	Boys
13	GSS K/Gayan	Zaria City	-	240	240	Girls
14	GGSS (WTC), Zaria	Zaria	-	278	278	Girls
15	GSSS Kaura	Zaria City	153	120	273	Co-education
16	GSS K/Kuyanbana	Zaria City	220	92	312	Co-education
17	Alhudahuda College	Zaria City	511	-	511	Boys
18	GSS Likoro (SNR)	Likoro	100	-	100	Boys
19	GSS Zaria SNR	Zaria City	150	-	150	Boys
	Total		**2744**	**2030**	**4624**	

Source: Zaria Educational Zone (2015)

3.4 Sample and Sampling Technique

Four co-education schools (4) were initially selected by the simple random sampling (ballot method) out of the nine (9) co-education schools in Zaria Educational Zone for good coverage representation and to avoid biasness that may arise from single sex schools. The school selected are namely: GSS Aminu, GSS Tudun Jukun, GSS Kuyanbana and GSSDakachi. The choice of the coeducation schools was to avoid research bias, which may arise from single sex schools.A pretest (GPT) was administered in each of these schools to forty (40) students. The result obtained was subjected to the analysis of variance (ANOVA) which was found to be significant. Consequently, the Scheffe's test was carried out to determine where the difference lies and ascertain schools with equivalent ability (see Appendix 16). The mean score obtained by students of GSS Aminu, GSS Dakachi and GSS K/ Kuyanbanawere found to be non-significant. Hence, these schools were appropriate for the study.

Two schools were then selected by simple random sampling from the three schools with the same ability. They areGSS K/ Kuyanbana (taken as the experimental school) and GSS Dakachi (as the control school).One intact classfrom the SS2 arm was selected by simple random method from each of these schools for the study. This was because the school administration did not allow disorganization of classes for the purpose of the study. Consequently, the researcher made use of the number of students found in the intact classes. Table 3.2 shows the sample for the study which comprised 72 students (male = 40 and female = 32) for the experimental group and 78 students (male = 42 and female = 30) for the control group. Hence, the total number of students for the study is 144 (male = 82 and female = 62).

Table 3.2: Sample Selected for the Study

S/No	Name of School	Status	M	F	Total
1	GSS K/ Kuyanbana	Experimental	*40*	*32*	72
2	GSS Dakachi	Control	42	30	72
	Total		**82**	**62**	**144**

3.5 Instrumentation

Two (2) instruments were used to collect data for the study; they are the Geometry Performance Test (GPT) and the Geometry Interest Inventory (GII). See appendices 1 and 2.

3.5.1 Geometry Performance Test (GPT)

Geometry performance Test (GPT) is a 40 item, 5 multiple choice objective test developed by the researcher based on units of geometry in the mathematics curriculum for senior secondary schools prepared by the Nigerian Educational Research and Development Council (NERDC) and the syllabi of the senior school certificate examinations of WAEC and NECO. This covers geometric ratios, triangles and polygons, circle geometry and loci (see appendix 1). GPT has two sections: section A is for collection of demographic data such as name of school, sex and age of respondents while section B is the multiple-choicequestions on geometry. The items measured only objectives in the cognitive domain in line with the Bloom's (1956) educational objectives. GPT was constructed by the guide of a Table of specification put together by the researcher, whichensures representation of each content area in the unit of study (see Table 3.3).

Table 3.3: Table of Specification for Geometry PerformanceTest based on Blooms Taxonomy

Objective/ Content	Weight	Knowledge	Comprehension	Application	Total
	%	40%	40%	20%	100.0%
Angles and Intercept	25.0	5	5	2	12
Triangles and Polygons	30.0	6	6	4	16
Circles	25.0	5	5	2	12
Loci	20.0	4	4	2	10
Total	**100.0**	**20**	**20**	10	**50**

3.5.2 Geometry Interest Inventory (GII)

The Geometry Interest Inventory (GII) is 20-item interest inventory adapted from Okigbo (2010). It comprised of open ended questions designed to draw out information from the students about their interest for geometry (see appendix 2). The 5-point Likert rating scale having responses of Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) and Strongly Disagree (SD) was used. These items were scored 5,4,3,2 and 1 respectively.

3.6 Validation of the Instrument

The validation of Geometry Performance Test (GPT) and Geometry Interest Inventory (GII) took the form of content and face validation. For GPT, the content validation ensured adherence to the Table of specification (Table 3.3). Three lecturers who are experts in the field of Mathematics Education and Psychology in the Department of Science Education, Department of Psychology and Counseling respectively from the Faculty of Education, Ahmadu Bello University, Zaria validated the instruments. Their criticism and observation were incorporated into the test items. For instance, where the researcherwrote mathematics, geometry was used instead so that questions or statements put up was more meaningful and precise.GII initially had thirty (30) items from which the

researcher chose twenty (20). Also, letter of introduction was given to the researcher by the Department of Science Education, to facilitate data collection from the sampled schools within the Educational Zone (see appendix9, 10, 11, 12, 13 & 14).

3.7 Pilot Testing

A Pilot test was conducted with forty (40) students (20 male and 20 female) of SS2 in GSS Bomo in Giwa Educational Zone which was not within the proximity of the selected schools for the study to test the appropriateness of the GPT and GII. This test facilitated the determination of the appropriate timing for each test and also problems which may affect the effective administration of the instruments to students in the actual research. GPT took55 minutes while GII took between 15 – 25 minutes to complete. The scores obtained from the pilot-test facilitated the determination of the reliability of the instruments which is a measure of their respective internal consistencies.

3.8 Reliability of Instrument

The reliability of Geometry Performance Test (GPT) and the Geometry Interest Interval were ascertained using the test-retest method. For GPT, its reliability was found to be 0.84 when the Pearson Product Moment Correlation was observed while for GII, 0.86 was obtained by the PPMC. Hence, the instruments are reliable.

3.9 Administration of Instruments

GPT and GII was administered to the students in both groups (experimental and control) of sampled schools before treatment was started as pretest. The result obtained facilitated the placement of students into home groups of four students each coded by alphabetic letters A, B, C … and so on as presented in Table 3.4.

Table 3.4: Home Group Plan

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	…	Group 18
A1 A2	B1 B2	C1 C2	D1 D2	E1 E2	F1 F2	…	R1 R2
A3 A4	B3 B4	C3 C4	D3 D4	E3 E4	F3 F4	…	R3 R4

In each home group, a member was given a number A1, A2, A3, and A4. These numbers determined the Expert Group [EG](see Table 3.5) a student consequently belonged to. Members in respective home groups with the same numbers studied a sub-topic in geometry.

Table 3.5: Expert Group Distribution Plan

EG1	EG 2	EG 3	EG 4
A1, B1, C1, D1	A2, B2, C2, D2	A3, B3, C3, D3	A4, B4, C4, D4
E1, F1, G1, H1	E2, F2, G2, H2	E3, F3, G3, H3	E4, F4, G4, H4
I1, J1, K1, L1, M1, N1, …R1	I2, J2, K2, L2, M2, N2, …R2	I3, J3, K3, L3, M3, N3, …R3	I4, J4, K4, L4, M4, N4, …R4

The sub-topics were distributed according to codes (1, 2, 3 & 4). Students with the same number code were in the same expert group and consequently studied the sub-topic in the expert material (see Table 3.6 and appendix 4).

Table 3.6: Expert Groups and Sub-topics

Sub-topics in Geometry apportioned to Expert groups
A1, B1, C1 … R1: Geometric ratios.
A2, B2, C2 … R2: Triangles and polygons.
A3, B3, C3 … R3: Circles geometry.
A4, B4, C4 … R4: Loci.

Upon completion of study, all students in the Expert group returned to their Home groups in line with the Jigsaw IV procedure. After home group interactions, the posttest (GPT & GII) was administered and individual score obtained. Students' interest level was ascertained using the 5 point Likert scale rating. The cut off point for acceptance is 3.00.

The male and female students were scored separately after the treatment to ascertain their relative achievement. Treatment to the experimental group lasted for 75 minutes three times a week for six weeks. In the control group, the normal school timetable for mathematics was followed for six weeks and the student taught same concepts by the lecture method. The control group was treated with the lecture (conventional) method using GPT and GII for both pretest and posttest. The flow chart (figure 3.2) shows the Jigsaw IV procedure presented in the treatment procedure.

3.9.1 Jigsaw IV Cooperative Learning Strategy (J4CLS)

The J4CLS is a method of learning developed by Holliday (2002) from earlier versions (Jigsaw 2 & 3) which involves organizing classroom activity that makes students dependent on each other to succeed. It breaks classes into groups and breaks assignments into pieces that the group assembles to complete the (jigsaw) puzzle.

The J4CLS process encourages each member of the group to play an essential part in the academic activity, work together as a team to accomplish a common goal and dependent on each other to succeed. It is a teamworkaffair, whichfacilitates interaction among all students in the class, leading them to value each other as contributors to their common task.

There are nine (9) steps involved in the J4LS procedure as postulated by Holliday (2002). They are as follows:

1. Introduction to the lesson
2. Expert sheets assigned to expert group
3. Groups answer expert questions prior to returning to home group
4. Quiz on material in the expert group groups checking for accuracy

5. Students return to home groups sharing information with teammates
6. Quiz on material shared checking for accuracy
7. Review process. Whole group by Jeopardy, Quiz Bowl etc.
8. Individual assessment and grading
9. Re-teach any material missed on assessment as needed.

3.9.2 Treatment to the Experimental Group

The J4CLS was treated to the experimental group only. This was done by the researcher and help of two (2) research assistants. The research assistants are mathematics teachers who had first degrees in mathematics education. These research assistants were trained for two days in the first week of the research by means of a J4CLS Training Manual developed by the researcher (see appendix 4).

The treatment period lasted for six weeks while the class sessions held every week for 2hours15 minutes per week. The lesson plans using the J4CLS applied to each sub-topic treated is presented in appendix 8. In addition, a flow chart of the J4CLS procedure is presented in Figure 3.2.

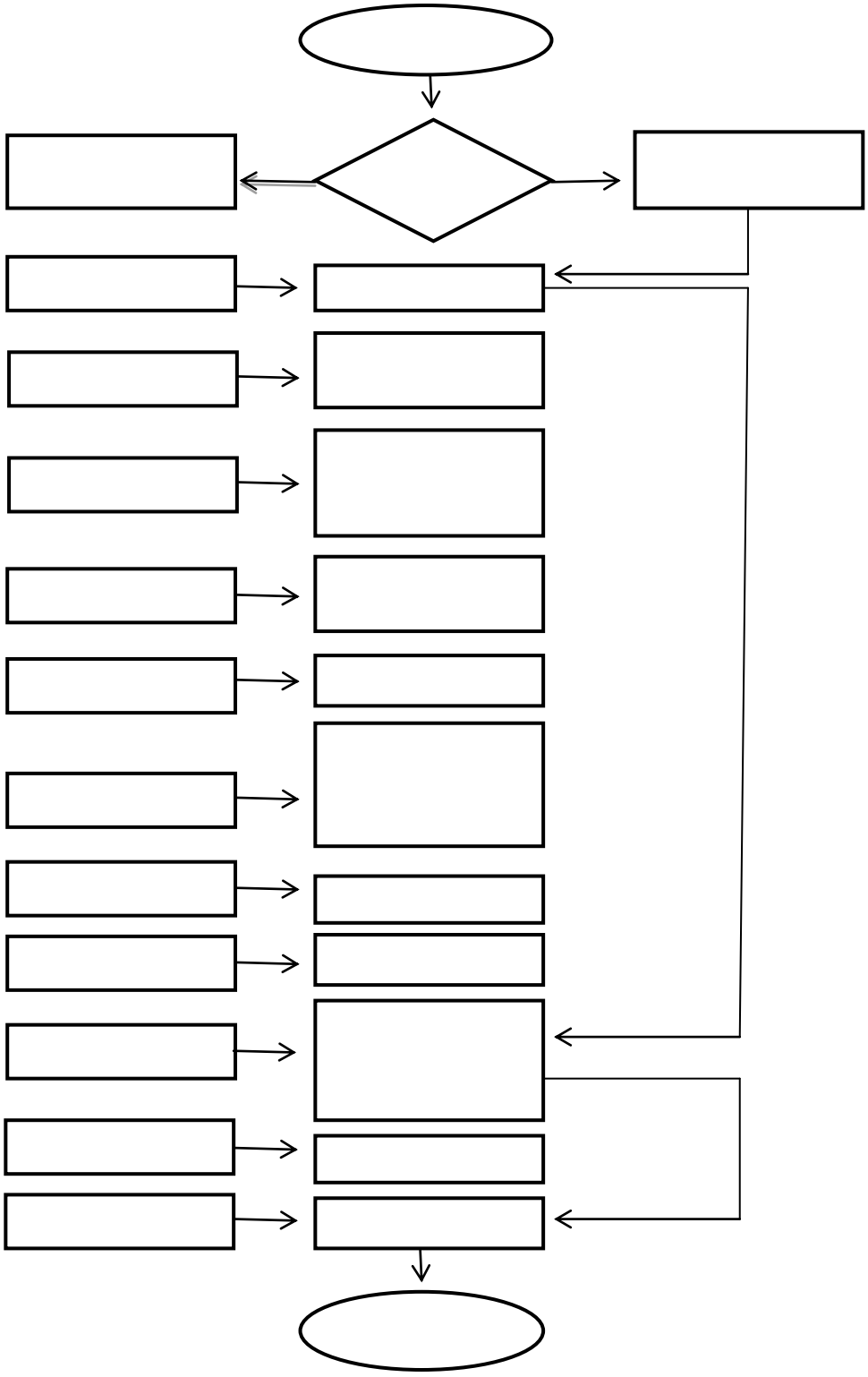


Figure 3.2: Flow chart of Jigsaw IV procedure
Source: Kagan (1994)

3.9.3 Teaching the Control Group

The students in the control group were taught the same concepts using the lecture method by the researcher and a trained research assistant who is a mathematics teacher in the school. The researcher ensures that the lesson plan designed for this purpose was strictly followed. The normal class time table for mathematics was used three times a week. The classes lasted for six weeks. The duration of each lesson was 45 minutes which summed up to 2 hours 15 minutes per week. Appendix 9 presents the lesson plan used in teaching the control group.

3.10 Data Collection Procedure

The GPT and GII were administered to the students in both groups (experimental and control) of sampled schools before treatment was started. This was followed by six weeks of treatment period. The students in the control group were taught same concepts by the conventional method by trained research assistants. GPT and GII was again administered to the students but the test items were re-arranged starting with even numbered items from the bottom. GPT lasted for 1 hour 15 minutes (75 minutes) but for GII, since the response time is indefinite, the students were given 30 minutes to complete the inventory. The research assistants in each school administered the instruments under the supervision of the researcher to avoid experimental bias.

In GPT each item was scored 2½ marks making a total of 100 marks for the 40 items. GII was scored 5, 4, 3, 2 and 1 point respectively for the options like Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) and Strongly Disagree (SD). A pre-test was administered to the students using the Geometry Performance Test (GPT) and the Geometry Interest Inventory (GII). This was followed by administration of the treatment

after which a post-test was be administered using the GPT and GII. The scores generated from the pre-test was then be compared with that of the post-test to determine whether or not there was a gain in achievement and improvement in interest among the students.

3.11 Procedure for Data Analysis

The data collected was used to answer the research questions and to test the hypotheses in sections 1.4 and 1.5 respectively. The research questions 1 and 2 were answered using the statistical mean and standard deviation obtained from Geometry Performance Test (GPT). The mean rank scores obtained from Geometry Interest Inventory (GII)was used to answer research questions 3 and 4.

Hypotheses 1 and 2 were analyzed using the t-test at $P \leq 0.05$ level of significance. For, hypotheses 3 and 4, the Kruskal-Wallis H-test at $P \leq 0.05$ level of significance was used to test for any significant difference. The Dun-Bonferroni post hocwas also utilized were the Kruskal-Wallis H-test was found to be significant to ascertain were the difference lies.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter dealt with the data presentation, analysis and discussion of the study effects of Jigsaw IV cooperative learning strategy (J4CLS) on interest and academic performance of secondary school students in geometry in Kaduna State. The study aimed at assessing the interest and performance of students in geometry when exposed to the J4CLS. Descriptive and statistical analysis of data collected were presented. The testing of the research hypotheses was carried out in the course of the presentation to enable the researcher draw some conclusions and make recommendations. The procedure is presented under the following headings:

4.2 Data Analysis and ResultsPresentation

4.3 Summary of Findings

4.4 Discussions

4.2 Data Analysis and Result Presentation

The data collected from the study using the instruments were analyzed, the result obtained were used to answer the research questions and testing the hypotheses. This section is divided into two: answers to research questions (section 4.2.1) and testing of hypotheses (section 4.2.2).

4.2.1 Answers to Research Questions

This section presented the answers to the research question asked in section 1.4.

Research Question 1

What is the difference in mean performance scores of students taught geometry using the Jigsaw IV cooperative learning strategy and those taught by the lecture method?

This question was answered by the descriptive statistics presented in Table 4.1.

Table 4.1: Descriptive Statistics for Performance between Experimental and Control Groups

Group	N	Mean	SD	Mean gain
Experimental	72	65.72	11.56	50.44
Control	72	36.44	10.65	28.39

Table 4.1 presents the mean scores and standard deviation scores of the experimental and control groups respectively. The experimental group had a higher mean score of 65.72 compared to that of the control group who had a mean score of 36.44. Also, the experimental group had a standard deviation score of 11.56 while the control group had 10.65 as its standard deviation. In terms of mean gain, the experimental had a higher mean gain of 50.44 compared to that of the control group who had 28.39. This implies that there is a difference in the mean and standard deviation scores of the two groups in favour of the experimental group.

Research Question 2

What is the difference in mean performance scores of male and female students taught geometry using the Jigsaw IV cooperative learning strategy?

To answer this question, the descriptive statistics was used as shown in Table 4.2

Table 4.2: Descriptive Statistics for Performance between Male and Female Students in the Experimental Group

Group	N	Mean Pretest	Mean Posttest	Mean Gain	SD Posttest
Male	40	12.35	66.10	53.75	12.65
Female	32	12.20	65.25	53.05	10.22

Table 4.2 presented the descriptive statistics of academic performance mean scores of male and female students who learnt geometry by the Jigsaw IV cooperative learning strategy only. The result showed that the male students had a higher mean score of 66.10 and their female counterpart had a mean score of 65.25. Their respective standard deviation scores were found to be 12.65 and 10.22.The mean gain of the male students group was 53.75 while that of the female students group is 53.05.

Research Question 3

What is the difference in mean interest score of students taught geometry using the Jigsaw IV cooperative learning strategy and those taught by the lecture method?

This question was answered by using the descriptive statistics presented in Table 4.3

Table 4.3: Summary of Mean Interest Scores of Experimental and Control Groups

Group	N	Mean Rank		Sum of Mean Ranks	Mean Rank Difference
		Pretest	Posttest		
Experimental	72	96.54	252.15	348.69	155.61
Control	72	74.18	155.13	229.31	80.95

From Table 4.3, the experimental group had a higher mean rank interest score of 252.15 compared to that of the control group who had 155.13 as mean rank interest score. The sum of mean ranks also showed similar trend with that of the experimental group (348.69)

higher than that of the control group (229.31). Also it was observed that the mean rank difference of the experimental and control groups is 155.61 and 80.95 respectively.

Research Question 4

What is the difference in mean interest score level of male and female students when taught geometry using the Jigsaw IV cooperative learning strategy?

The descriptive statistics presented in Table 4.4 was used in answering this question.

Table 4.4: Summary of Mean Interest Scores of Male and Female Students in the Experimental and Control Groups

Group	Sex	N	Mean Rank	Sum of Ranks	Mean Rank Difference
Experimental	Male	40	108.45	216.17	0.73
	Female	32	107.72		
Control	Male	42	38.33	73.11	3.55
	Female	30	34.78		

The summary of mean interest score presented in Table 4.4 revealed a mean rank interest score of 108.45 and 107.72 respectively for male and female students in the experimental group. In the control group, the mean rank interest score for male and female students was found to be 38.33 and 34.78 respectively. However, the sum of mean ranks with respect to gender for both groups was observed to be 216.17 and 73.11. Gender wise, the mean rank difference interest score for the male and female students (0.73) was observed to be lower than that of the male and female students in the control group.

4.2.2 Test of Hypotheses

This section presented the testing of the null hypotheses stated in section 1.5 at $P \leq 0.05$ level of significance. The analysis of the result is presented as follows:

Null Hypothesis 1

There is no significant difference in the mean performance scores of students taught geometry using the Jigsaw IV cooperative learning strategy and those taught using the lecture method.

To test this hypothesis, the mean scores obtained from the Geometry Performance Test (Table 4.1) of the experimental and control groups were subjected to the independent t-test statisticsat $P \leq 0.05$as shown in Table 4.5.

Table 4.5: Independent t-test for Performance between Experimental and Control Groups

Group	N	Mean	SD	df	t-value	P-value	Decision
Experimental	72	65.72	11.56				
				142	14.81	0.001*	Reject H_{o1}
Control	72	36.44	10.65				

***Significant at $P \leq 0.05$

From Table 4.5, the t-value of 14.81 has a corresponding P-value of 0.001 at 142 degrees of freedom, which was less than P-value of 0.05 level of significance. P = 0.001 is significant hence, the null hypothesis one (**H_{o1}**) was rejected. This meant that there was a significant difference between geometry performance of the experimental and control groups. The result therefore showed that the Jigsaw IV cooperative learning strategy is more effective than the lecture method in improving students' academic performance in

geometry.This wasconnected to the nature of the Jigsaw IV cooperative learning strategy, which is a student-centered teaching approach.

Null Hypothesis 2

There is no significant difference in the mean performance scores of male and female students taught geometry using the Jigsaw IV cooperative learning strategy.

To test this hypothesis, the mean scores obtained from the Geometry Performance Test in Table 4.2 of male and female students in the experimental group was compared using the independent t-test statistic as presented in Table 4.6.

Table 4.6: Independent t-test for Performance between Male and Female Students in the Experimental Group (Posttest)

Group	N	Mean	SD	df	t-value	P-value	Remarks
Male	40	66.10	12.65				
				70	0.31	0.759*	Retain H_{o2}
Female	32	65.25	10.22				

***Not Significant at P □ 0.05

Table 4.6 revealed that a P-value of 0.759 was obtained from the t-value of 0.308 at 70 degrees of freedom. This value is not significant since P = 0.759 is greater than P = 0.05 level of significance. Therefore, the null hypothesis two ($\mathbf{H_{o2}}$) was retained. This implied that there was no significant difference between geometry performance of male and female students in the experimental group when exposed to the Jigsaw IV cooperative learning strategy. The result therefore showed that the Jigsaw IV cooperative learning strategy is a gender friendly teaching methodology.

Null Hypothesis 3

There is no significant difference in mean interest level of students in geometry when taught using the Jigsaw IV cooperative learning strategyand those taught by the lecture method.

This hypothesis was analyzed using the mean scores in Geometry Interest Inventory (Table 4.3) of experimental and control groups (pretest and posttest). This is shown in Table 4.7.

Table 4.7: Summary of Kruskal-Wallis Test for Mean Interest Scores of Experimental and Control Groups

Group	N	Mean Rank	df	H-value	P-value	Remark
Experimental	72	252.13				
			3	197.00	0.001*	Reject H_{o3}
Control	72	155.13				

*Significant at $P \leq 0.05$

Table 4.7 revealed a H-value of 197.00 at 3 degree of freedom corresponds to the P-value of 0.001 is significant at $P \leq 0.05$. Hence, the null hypotheses three ($\mathbf{H_{o3}}$) is hereby rejected. This implies that there is a significant difference in the interest level of the experimental and control groups.

Null Hypothesis 4

There is no significant difference in the mean interest level of male and female students in geometry when taught by the Jigsaw IV cooperative learning strategy.

To analyze this hypothesis, the mean scores for Geometry Interest (Table 4.4) of the male and female students was subjected to the independent t-test statistics at $P \leq 0.05$as shown in Table 4.8.

Table 4.8: Summary of Kruskal-Wallis Mean Interest Scores for Male and Female Students in the Experimental and Control Groups

Group	Sex	N	Mean Rank	df	H-value	P-value	Remark
Experimental	Male	40	108.45	3	105.56	0.001*	Reject H_{o4}
	Female	32	107.72				
Control	Male	42	38.33				
	Female	30	34.78				

*Significant at $P \leq 0.05$

Table 4.8 revealed a H-value of 105.56 at 3 degree of freedom gave a P-value of 0.001. This value is significant at $P \leq 0.05$. Therefore, the null hypothesis four is hereby rejected. Hence, it was concluded that a significant difference exists between the groups in terms of gender interest level. In order to ascertain which of the groups is significantly different from the others the data was subject to the Dunn-Bonferroni post hoc test for pairwise comparison. This is presented in Table 4.9.

Table 4.9: Summary of Dunn-Bonferroni Post Hoc Test Pairwise Comparison

Group Comparison	Test Statistic	Std. Error	Std. Test Statistic	P-value	Remark
Female control / Male control	3.550	9.958	0.356	0.721	NS
Female control/ Female Experiment	-72.933	10.756	-6.781	0.001*	S
Female control/ Male Experiment	-73.669	9.958	-7.398	0.001*	S
Male control/ Female Experiment	-69.383	9.958	-6.967	0.001*	S
Male control/ Male Experiment	-70.119	9.091	-7.713	0.001*	S
Female Experiment / Male Experiment	0.736	9.958	0.74	0.941	NS

*Significant at $P \leq 0.05$

Table 4.9 revealed that the pairwise comparison of the male/female students in the control group and that of the male and female students in the experimental group was not

significant at $P \leq 0.05$. Other pairwise comparisons were found to be significant at $P \leq 0.05$. This implies that the lecture method and the J4CLS are both gender friendly.

4.3 Summary of Major Findings

The data collected were analyzed to answer four research questions and test four null hypotheses formulated in section 1.4 and 1.5 of this study. From the data analyzed, the following findings were observed:

1. There wasa significant difference between the mean performance scores of students taught geometry using the Jigsaw IV cooperative learning strategy and those taught using the lecture method.
2. There was no significant difference between the mean performance scores of male and female students taught geometry using the Jigsaw IV cooperative learning strategy.
3. There wasa significant difference between the interest level of students taught geometry using the Jigsaw IV cooperative learning strategy and those taught by the lecture method.
4. There was no significant difference between the interest level of male and female students taught geometry using the Jigsaw IV cooperative learning strategy.
5. There was no significant difference between the interest level of male and female students taught geometry using the lecture method.

4.4 Discussions

The aim of this study was to assess the efficacy of Jigsaw IV Cooperative Learning Strategy (J4CLS) on the academic performance of secondary school students in geometry

in Kaduna State, Nigeria. Four topics namely Angles and intercept, triangles and polygon, circle geometry and loci were examined in the study. The students in both the experimental and the control groups used in the study had equivalent knowledge of geometry as determined by the result of the pretest (ANOVA and Scheffe's test Appendix 15) administered before the treatment commenced. Therefore, the differences observed were due to treatment. The results of data on research questions null hypotheses tested are discussed as follows:

The result in Table 4.1 showed that there is a difference in the mean and standard deviation scores of the experimental and control groups in favour of the latter. This difference was subjected a t-test in Table 4.5. The Table revealed that the difference observed was significant. The students exposed to the Jigsaw IV cooperative learning strategy had a higher mean gain of 50.44 compared to those taught by the lecture method who had a mean gain of 28.39. This gain in favour of the experimental group was also observed in the groups standard deviation scores. This implied that the use of Jigsaw IV cooperative learning strategy improved students' academic performance in geometry.

This finding is in line with that of Jansoon, Somsook and Coll (2008), Maden (2010), Fini, Zainlipour and Jamri (2012) and Mari (2015) who found out that the Jigsaw IV Cooperative Learning Strategy (J4CLS) was effective in enhancing students' performance in school based subjects like mathematics. They found a significance difference in performance in favour of the experimental group. This is evidenced in the higher mean scores obtained by students in the experimental groups of their respective studies when compared to other methods of learning. Also, Kolawole (2008) and Chiason, Kurumeh and Obida (2011) in separate studies found that the cooperative learning strategy

is effective in the teaching and learning of geometry and mathematics; they recommended the use of cooperative learning strategy in the teaching and learning of mathematics in Nigerian schools.

The result obtained from Table 4.2 revealed a higher posttest mean performance score of 66.10and standard deviation score of 12.65for the male students compared to that of the female students who had a posttest mean performance score of 65.25 and standard deviation score of 10.22. It was observed that the male students had a slightly higher mean gain of 53.75 compared to the female students mean gain of 53.05. Consequently, this difference was subjected to the t-test analysis as shown in Table 4.6. The Table revealed the observed difference was not significant. This finding is in agreement with that of Mbacho and Githua (2013) and Iji et al (2014) who reported that there was no significant gender difference in achievement when students were exposed to the Jigsaw CLS. Further, this study confirms the findings of Lindberg, Hyde, Petersen and Linn (2010) who found no significance difference between the performance of male and female students in mathematics in general. The authors concluded that this is due to a global closure in the performance of female in contrast to the dominance of their male counterpart in the subject as many literatures suggested.

Table 4.3 presented the respective summary of mean rank interest of the experimental and control groups. The Table revealed that the experimental group had a higher mean rank difference 155.61 compared to that of the control group of 80.95. This implied that the Jigsaw IV cooperative learning enhances the interest level of students. In order to ascertain the significance of the observed difference in interest level, the data was subjected to a Kruskal-Wallis H-test presented in Table 4.7. The result revealed that the

observed difference was significant; hence, the null hypothesis four was rejected. This implied that the Jigsaw IV cooperative learning strategy is a better method at improving students' interest in geometry than the lecture method.This finding is in line with Duff (2012), Mbacho and Githua (2013) and Tran (2014) who asserted that due to the student-centered nature of the Jigsaw cooperative learning, interest is promoted because the strategy stimulates cognitive activities.

Table 4.4revealed a difference in mean rank interest between male and female students in the experimental group and control groups. The difference in mean rank interest for male and female students in the experimental group was found to be 0.73 while that of the male and female students in the control group was 3.55. The data was subjected to the further analysis in order to ascertain if the observed difference was significant. Table 4.8 is aKruskal-Wallis test analysis of the difference in mean interest level of male and female students in the experimental and control groups. It showed that the difference was significant. Consequently, the Dunn-Bonfferoni post hoc test was carried out. From Table 4.9 it was observed that the pairwise comparison of male/female students in the control group and that of the male/female students in the experimental group was not significant. at P □ 0.05. This implied that the lecture method and the J4CLS are both gender friendly teaching methods with respect to interest of students in geometry.This confirms the findings of Mbacho and Githua (2013) and Tran (2014) who found no significant difference in interest when male and female students were exposed to the Jigsaw cooperative learning strategy.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This study determined the effects of Jigsaw IV cooperative learning on interest and academic performance of secondary school students in geometry in Kaduna State. The objective of the study was to assess the interest and performance of students in geometry when exposed to the Jigsaw IV cooperative learning. This chapter summarized the whole study under the following headings:summary, conclusion and recommendations. It also gave suggestions for further research.

5.2 Summary

The aim of the study was to assess the effects of Jigsaw IV cooperative learning on interest and academic performance of secondary school students in geometry in Kaduna State. The issue of poor performance and lack of interest in geometry among secondary school students was the problem this study addressed. This problemhascontinued to affect achievement in mathematics despite the importance of the subject to nation building and development. The instructional method employed by the teacher plays an important role in the acquisition of instructional content for meaningful learning and development of necessary mathematical skills. Nigerian secondary school classrooms are predominantly dominated by the lecture (conventional) method of instruction which does not encourage student-student interaction. The lack of active participation of students is their learning was also indicted for students' poor performances in geometry. Research in many areas of education has shown that the method of teaching utilized by the teacher is an important factor in students' learning and subsequent performance in examinations. A learning

strategy, which is result oriented and is capable of improving students' interest and performance in geometry and mathematics in general, can save the situation. Based on the above, this study assessed the effects of Jigsaw IV cooperative learning strategy on interest and academic performance of secondary school students in geometry in Kaduna State, Nigeria.

Specifically, the study assessed:

i. the effect of Jigsaw IV cooperative learning strategy and lecture method on students' academic performance in geometry.
ii. the level of interest in geometry of students when exposed to the Jigsaw IV cooperative learning strategy and lecture method.
iii. the performance of male and female students when exposed to the Jigsaw IV cooperative learning strategy and the lecture method.
iv. the level of interest of male and female students when exposed to the Jigsaw IV cooperative learning strategy and lecture method.

Four research questions and four hypotheses which guided the study were answered, tested and reported. The quasi-experimental research design was utilized. The population of the study comprised students of SS2 in public senior secondary schools in Zaria Educational Zone (ZEZ) of Kaduna State. Four schools were first selected by the simple random sampling method from the nine coeducation schools in ZEZ. These schools were pretested on Geometry Performance Test (GPT) and the result obtained was subjected to the analysis of variance (ANOVA) and the Scheffe's test. Finally, two schools of equivalent ability were chosen for the research. From these schools, two intact classes were

then chosen by the simple random technique as sample for the study which comprised 144 students (experimental = 72; control = 72).

Two (2) instruments were used to collect data for the study; they are the Geometry Performance Test (GPT) and the Geometry Interest Inventory (GII). GPT is a 40 item, 5 multiple choice objective test based on geometry in accordance with the mathematics curriculum for senior secondary schools prepared by the Nigerian Educational Research and Development Council (NERDC) and the syllabi of the school certificate examinations of WAEC and NECO for geometric ratios, triangles and polygons, circle geometry and loci (see appendix 1). While GII consisted of 20-item inventory adapted from Okigbo (2010) which comprised open ended questions designed to draw out information from the students about their interest for geometry (see appendix 3). The 5-point Likert rating scale of Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) and Strongly Disagree (SDA) was used to score students responses.

The data collected were analyzed and from it, the research questions were answered descriptively by the statistical mean scores, standard deviation and mean rank scores while the research hypotheses were analyzed using the analysis of variance (ANOVA), Sheffe's post hoc test, t-test, Kruskal-Wallis test and the Dunn-Bonfferoni post hoc test at $P \leq 0.05$ level of significance.The computer software SPSS (version 21)was used in the computation of results (see appendices 16- 21). The treatment and control procedures as well as the administration of instruments was done by researcher and trained research assistants.

The result of the analysis of data is summarized as follows:

Students taught geometry using the Jigsaw IV cooperative learning Strategy (J4CLS) had a higher mean performance score compared to those taught by the lecture

method. Also, a significant difference was found between the students taught geometry using the J4CLS and those taught using the lecture method. This results implied that the J4CLS was more effective in improving students' performance in geometry.A very slight difference was observed in the mean performance score of students with respect to gender in favour of the male students. This difference was not significant when further analysis was done. Hence, J4CLS is a gender friendly strategy.

In terms of interest in geometry, the students taught by the J4CLS had a higher mean rank score for geometry interest level compared to their counterpart taught using the lecture method. Also, a significant difference was found between the interest level of students taught geometry using the J4CLS and those taught by the lecture method.

When the interest level of students taught geometry was compared with respect to gender in the groups, it was found to be significant. This difference was not significant when further analyzed for male/female in the experimental group and also for male/female in the lecture group. Hence, the J4CLS and the lecture method are both gender friendly method of teaching with respect to students' interest in the study of geometry.

5.3 Conclusions

The study was on the effects of Jigsaw IV cooperative learning strategy on interest and academic performance of secondary school students in geometry in Kaduna State, Nigeria. From the findings of the study, which was based on the descriptive and statistical analyses of data collected and presented in chapter four, the following conclusions was arrived at.

The Jigsaw IV cooperative learning strategy (J4CLS) was more effective at improving students' performance in geometry compared to the lecture method. This is

evident in the higher mean performance scores obtained by students who were exposed to it. It was also observed that it is gender unbiased since male and female students perform equally well.

The J4CLS was observed to improve students' interest in geometry better than the lecture method. This follows from the higher mean rank interest level gained by the students exposed to it. However, the J4CLS and the lecture method were observed to be gender friendly teaching methods in terms of interest since male and female students taught using the respective methods had equivalent interest level for geometry.

5.4 Contribution to Knowledge

The J4CLS performance is a result oriented pedagogical approach for improving students'performance in geometry. The strategy is also gender friendly and facilitate team spirit by breaking barriers to learning such as inferiority complex and gender restriction that can frustrate collaborative efforts.

The J4CLS is a platform that brings about increased interest for the learning of geometry among students and facilitates better attitude toward the learning of mathematics. With respect to interest, J4CLSis a friendly teaching method capable of improving male and female students interest proportionally.

Due to the nature of the J4CLS being a student-centered approach, collabo efforts among students can lead to the development of skills such as visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proofs. These skills are very useful in higher mathematics. Also, the findings of the study added new knowledge to the existing literature on J4CLS and the improvement of students'interest and performance in geometry.

5.5 Recommendations

Based on the findings in chapter four and the conclusions of the study, the following recommendations are made:

1. Teachers should employ the J4CLS in the teaching of geometry in senior secondary schools' classroom to enhance students' performance and interest at it since the strategy is student-centered based. The strategy also facilitates the learning of much material in limited time which can help the teacher and students cover large portions of the school syllabus.
2. Students should be encouraged by their teachers to participate in the J4CLS because it is a result oriented strategy that has the potential of improving their interest and performance in mathematics. It also opens them up to the skill of leadership, tolerance and collaborative efforts that will be needed for success in their careers and life.
3. Workshops and seminars for mathematics and science based teacher should be organized by the Ministry of Educationfor each Education Zone of Kaduna State on the use of the J4CLS in classroom.
4. Curriculum planners such as Ministry of Educationshould officially make J4CLS a valid method for teaching and learning of mathematics topics like geometry in secondary schools.
5. Textbook writers should include the J4CLS as a method for teaching geometry and mathematics. This will popularize and make J4CLS acceptable among teachers.

5.6 Implications of findings of the Study

The findings of this study has some important implications that will be useful for the teaching and learning of geometry and mathematics in generally. They are as follows:

Geometry pedagogy can be improved if the right methodology is employed. This is because the poor performance of students in mathematics has been linked to inappropriate methodology utilized in its teaching. The J4CLS is one of such platform that can be utilized.The gender gap in mathematical reasoning and geometry which has been reported in favour of male students can be bridged by the J4CLS. This is because itis teaching method that is capable of producing better confidence in female students through its collaborative potential.

The potential embedded in J4CLS can promote better performance, interest, attitude and collabo efforts that is needed for career and individual development in other fields of endeavour among students.The J4CLS can be employed by teachers to accelerate learning of materials where the need arises.

5.7 Limitations of the Study

The study has the following limitations:

1. The J4CLS can be difficult to implement but with patience, students and teachers can achieve a lot. It can also be noisy and needing bigger classrooms than the ones the researcher used in the study due to large number of students.
2. Getting male and female students,work together in a team can be a bit tasking especially where there is inferiority complex among the female students.

5.8 Suggestions for Further Studies

1. Similar study can be carried out in secondary schools in other states of the federation to ascertain if similar findings will hold.
2. A study on the effects of J4CLS on the academic performance, attitude and retention of students in geometry can be carried out among secondary school students, polytechnic, colleges of education and undergraduates of universities in Nigeria.

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Appendix 1

Geometry Performance Test

School ……

Age ……Sex ……

Dear students,

Read each question carefully and answer the questions that follows by ticking (√) only one of the options.

1. XYZ is a straight line such that |XY|= |YZ| = 3cm. A point moves in plane of XYZ so that |PY|≤ |XY|. Which of the following describes the locus of P?

A. Line through X perpendicular to $\overline{XZ}$
B. Line through Y perpendicular to $\overline{XZ}$
C. Line through Z perpendicular to $\overline{XZ}$
D. circular disc, centre X, radius 3 cm
E. circular disc, centre Y, radius 3 cm

2. A circle, centre O, radius 5cm, is drawn on a sheet of paper. A point moves on the paper so that it is always 2cm from circle. The locus of P is

A. a circle, centre O radius 3cm
B. two circles, centre O, radii 3cm and 7cm
C. a circle, centre O radius 6cm
D. two circles, centre O, radii 4cm and 6cm
E. a circle, centre O radius 3.5cm

3. Which of these statements describes a locus of points at a given distance from a fixed.

A. a spherical surface of radius x
B. a perpendicular bisector
C. a circle of radii 3 cm
D. a straight line
E. a circle of radius x

4. Locus of points at a given distance from a straight-line|XY|.

A. a parallel line to |XY|
B. a perpendicular bisector of |XY|
C. two straight line parallel from to |XY|
D. a straight line to |XY|
E. a loci of |XY|

5. The locus of points equidistance from two given points |KL| describes a__

A. a parallel line to |KL|
B. a perpendicular bisector of |KL|
C. a straight line parallel from to |KL|
D. a loop of |KL|
E. a loci of |KL|

6. The locus of points equidistant from two straight lines is said to be -

A. a pair of bisectors of the angles between the lines
B. a perpendicular bisector of angle of the lines|
C. a straight line between the lines |
D. a loop of between the lines
E. an intersect of the lines between the angles

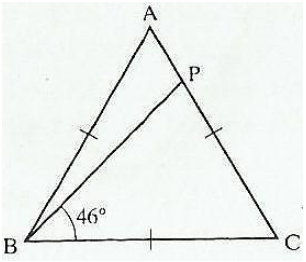
7. Two triangles are said to be congruent if
A. they have three sides
B. they look similar to each other
C. they have exactly the same shape and size
D. they have ambiguous case
E. they are equilateral triangles.

8. The angles of a quadrilateral taken in order, are x, 5x, 4x and 2x. The size of its largest angle will be_
9. 240^o B. 180^o C. 30^o D. 150^o E. 120^o

10. In a parallelogram, which of the following statements is/are true?
I. **the opposite sides are equal**
II. **the opposite angles are equal**
III. **the opposite sides are parallel**
IV. **the diagonals bisect one another**

A. I and II only
B. II and III only
C. II, III and IV only
D. I and III only
E. I, II, III and IV

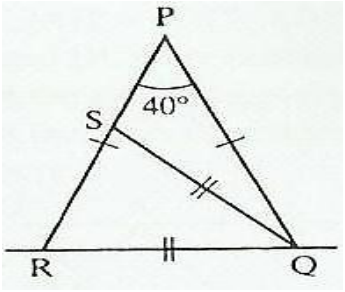
11. In the figure below, ABC is an equilateral triangle. P is point on $\overline{AC}$ such that $P\hat{B}C = 46^o$. Calculate $A\hat{P}B$



A. 74^o B. 60^o C. 16^o D. 90^o E. 106^o

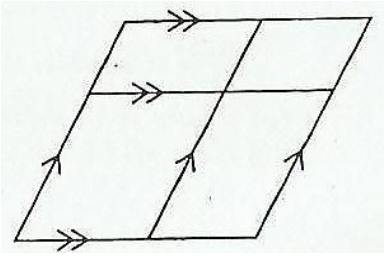
12. Given the triangle below such that

|PR| = |PQ| and |QS| = |QR| and $R\widehat{P}Q = 40^o$ then the value of $P\widehat{Q}S$ =?



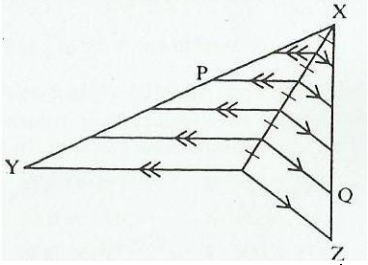
A. 70^o B. 30^o C. 90^o D. 40^o E. 110^o

13. How many parallelograms are there in the figure below?



A. 7 B. 3C. 9 D. 5 E. 11

Use the figure below to answer questions 13, 14, 15 and 16.



14. What is the ratio $\frac{|XP|}{|XY|}$?

A. $\frac{1}{5}$ B. $\frac{2}{5}$ C. $\frac{4}{5}$ D. $\frac{3}{5}$ E. $\frac{5}{6}$

15. What is the ratio $\frac{|ZQ|}{|QX|}$?

A. $\frac{1}{5}$ **B.** $\frac{2}{5}$ **C.** $\frac{4}{5}$ **D.** $\frac{3}{5}$ **E.** $\frac{5}{6}$

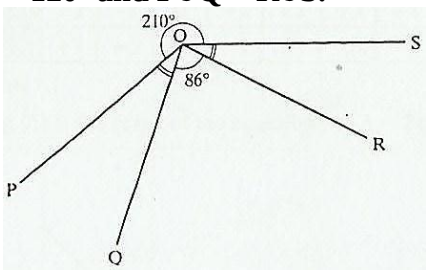
16. If |XP| = 9, what is |XY|?

A. 13.5 B. 22.5C. 18.0 D. 2.25 E. 225

17. If |ZQ| = 3.5, what is |QX|?

A. 7 B. 13.5C. 9 D. 27 E. 14

18. what is the value of $P\hat{O}Q$ in the figure below given that $Q\hat{O}R = 86^o$, reflex $P\hat{O}S = 120^o$ and $P\hat{O}Q = R\hat{O}S$.



A. 32^o B. 43^o C. 50^o D. 75^o E. 64^o

19. The sum of the interior angles of any n-sided convex polygon is

A. (2n-2) right angles
B. (2n-3) right angles
C. (2n-4) right angles
D. (2n-6) right angles
E. (4n-2) right angles

20. If the angles of a pentagon are x, 2x, (x + 30), (x - 10) and (x + 40), x =

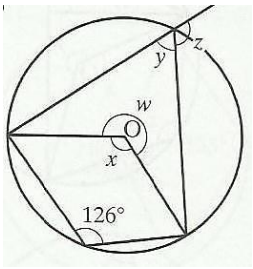
A. 108^o B. 80^o C. 60^o D. 50^o E. 30^o

21. Which of these statements is true

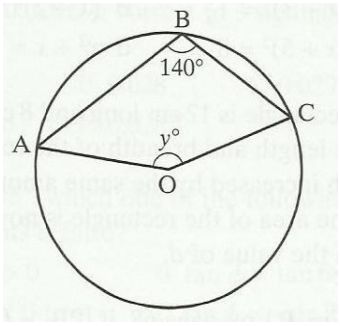
I. **the vertices of cyclic quadrilateral lie on the circumference**
II. **the opposite angles of a cyclic quadrilateral is 180^o**
III. **the angle in a semicircle is 90^o**
IV. **a diameter is chord**

A. I and II only
B. I, II and III only
C. None of the above
D. I and III only
E. all of the above

22. The value of the angles marked x and y respectively in the figure below are



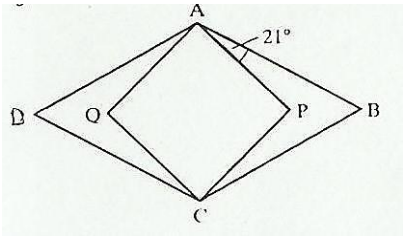
A. 63^o and 126^o
B. 252^o and 146^o
C. 108^o and 54^o
D. 54^o and 108^o
E. 126^o and 63^o



23. In the figure above, O is the centre of the circle. Given that $A\hat{B}C = 140^o$. Find y

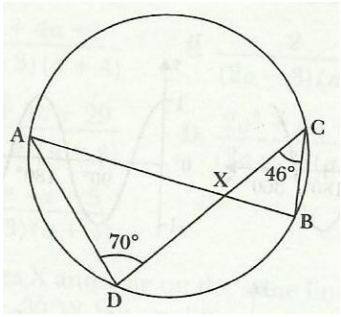
A. 20^o B. 80^o C. 70^o D. 240^o E. 280^o

24. ABCD is a rhombus and APCQ is a square. If $P\hat{A}B = 21^o$, calculate the four angles of ABCD



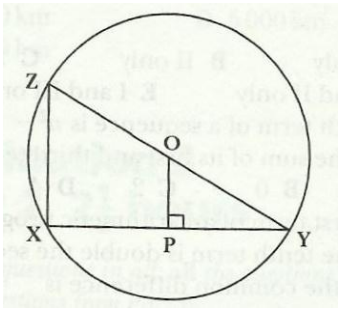
A. 132^o, 48^o, 132^o and 48^o
B. 96^o, 148^o, 96^o and 148^o
C. 102^o, 48^o, 102^o and 48^o
D. 42^o, 90^o, 42^o and 90^o
E. 150^o, 30^o, 150^o and 30^o

25. In the figure below, $D\hat{C}B = 46^o$ and $A\hat{D}C = 70^o$. Find $C\hat{X}B$



A. 84^o B. 64^o C. 70^o D. 46^o E. 44^o

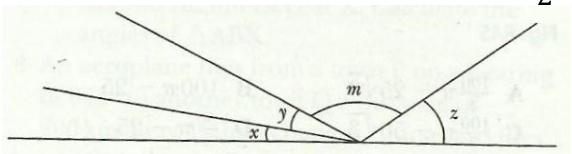
26. The figure below shows a circle XYZ with centre O. OP is a perpendicular to the chord XY. Find the ratio
|XZ| : |PO|



A. 5:2 B. 3:1C. 2:1 D. 1:1 E. 1:2

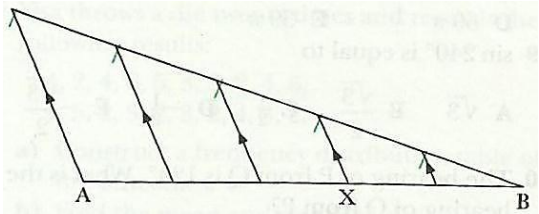
27. Find m in the figure below given that

$$m = \frac{1}{2}(x + y + z)$$



A. 45^o B. 60^o C. 90^o D. 46^o E. 150^o

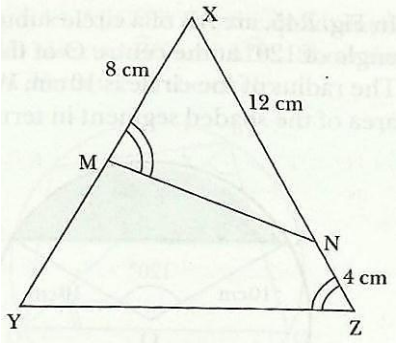
28. What is the ratio of |AB|= |XB| in the figure below



A. 2:3 B. 3:2C. 1:3 D. 5:2 E. 2:5

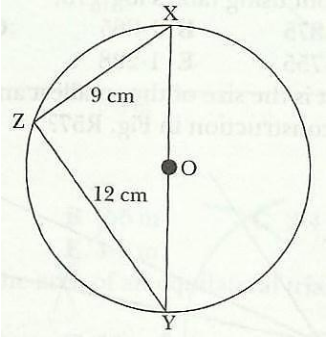
29. In the figure below, |MX| = 8cm,
|XN| = 12cm, |NZ| = 4cm and

$X\hat{M}N = X\hat{Z}Y$. Calculate |YM|



A. 32cm B. 16cmC. 12cm
D. 24cm E. 6cm

30. The figure below shows that $\overline{XY}$ is a diameter of the circle with centre O. |XZ| = 9cm and |YZ| = 12cm. Find the radius of the circle.

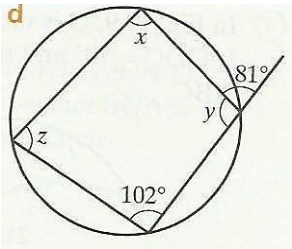


A. $4\frac{1}{2}$cm **B. 6cmC.** $7\frac{1}{2}$cm
D. 9 cm E. $10\frac{1}{2}$cm

31. The bisector of an angle in a triangle divides the opposite side in the ratio of the sides___

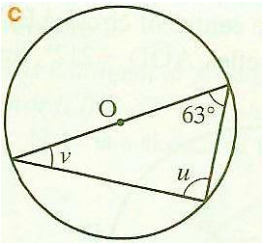
A. Opposite the angle
B. Alternate to the side
C. Containing the sides
D. Containing the angle
E. Containing the bisector

32. In the figure below, what is the value of the angle marked z?



A. **95^oB. 99^o C. 101^oD. 109^oE. 80^o**

33. The values of the angles marked u and v in the figure below are ____



A. 90^o and 27^oB. 180^o and 27^o
C. 70^o and 27^oD. 24^o and 77^o
E. 28^o and 90^o

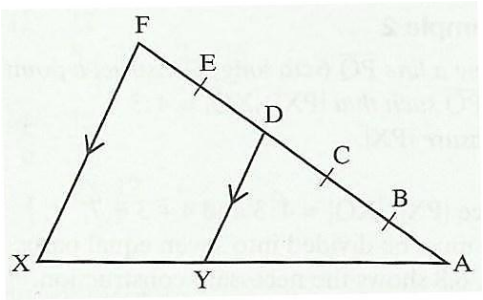
34. The line joining the midpoints of two sides of a triangle is parallel to the third side and ___

A. equal to the opposite side
B. alternate to half of it
C. one-third of the other side
D. equal to half of it
E. bisects the parallel side

35. A line parallel to one side of a triangle divides the other two sides _

A. into equal length
B. in the same ratio
C. one-third of the other side
D. equal to half of it
E. in the same diagonal

36.



In the figure above, $\overline{AF}$ is divided so that |AB| = |BC| = |CD| = |DE| = |EF| and $\overline{FX}||\overline{DY}$. If |AY| = 7.5 cm, what is |XY|?

A. 5.5cm B. 5.25cmC. 5.0cm D. 3.25cm E. 7.5cm

37. The angle that an arc of a circle subtends at the centre is twice that which it subtends at any point on the ___

A. remaining part of the circle
B. remaining part of the circumference
C. remaining part of the arc
D. remaining part of the segment
E. remaining part of chord

38. A straight line drawn from the centre of a circle to bisect a chord which is not a diameter makes is at a _____

A. 120^o to the chord
B. 180^o to the chord
C. 45^o to the chord
D. 75^o to the chord
E. 90^o to the chord

39. The exterior angle of a cyclic quadrilateral is equal to ___

A. the supplementary angle
B. parallel angles
C. the interior opposite angle
D. the other two sides
E. half the other angles

40. ABCD is a quadrilateral such that $A\hat{B}C = A\hat{D}C$ $90^o$and |AD| = |BC|. Which one of the following angles is equal to $B\hat{A}C$?

A. $A\hat{C}B$ B.$A\hat{C}D$ C.$A\hat{D}B$ D.$C\hat{A}D$ E. $C\hat{B}D$

Answers to Geometry Performance Test (GAT)

S/ No	Answer	S/ No	Answer
1	E	21	E
2	B	22	D
3	B	23	C
4	B	24	A
5	D	25	A
6	C	26	C
7	C	27	E
8	D	28	D
9	D	29	E
10	E	30	C
11	E	31	D
12	B	32	B
13	A	33	A
14	D	34	D
15	A	35	B
16	B	36	C
17	D	37	B
18	A	38	E
19	A	39	C
20	E	40	B

Appendix 2

Geometry Interest Inventory (GII)

Preliminary Information

School ……

Age ……Sex ……

Dear students,

Read each statement carefully and indicate the type of work in which you are interested and which you enjoy doing. Tick (√) in the options that agrees with your view. Use the Key Below:

SA = Strongly Agree
A = Agree
UD = Undecided
DA = Disagree
SDA = Strongly Disagree

S/No	Items	SA	A	UD	DA	SDA
1.	I try to solve difficult problems of geometry myself rather than asking others					
2.	Be in class when it is time for a geometry lesson					
3.	I sometimes disturb and distract others in a geometry class					
4.	I feel happy in the absence of geometry teacher					
5.	I devote free time to study any other subject apart from geometry.					
6.	I like designing and build geometric shapes.					
7.	I take part in geometry lessons.					
8.	I enjoy doing geometry assignments.					
9.	I like doing any geometry related jobs leaving school					
10.	I sometimes leave class when it is time for geometry lessons.					
11.	I would like to study further any course involving geometry.					
12.	I devote free time to study geometry.					

13.	I sometimes feel tired doing geometry assignments.					
14.	I like engaging in activities related to geometry.					
15.	I sometimes teach other students geometry.					
16.	I enjoy taking part in any discussion about the importance of geometry in everyday life.					
17.	I like discussing what I learnt about geometry with my parents and younger one.					
18.	I feel insecure in geometry class					
19.	I like to lead a group in practical work in geometry classroom.					
20.	I enjoy finding solution to challenging problems in geometry.					

Appendix 3

Expert group 1

Expert sheet: Angles and Intercept on parallel lines

Content

i. Angles at a point add up to 360.

ii. Adjacent angles on a straight line are supplementary.

iii. Vertically opposite angles are equal.

iv. Alternate angles are equal.

v. Corresponding angles are equal.

vi. Interior opposite angles are supplementary.

vii. Intercept theorem

Expert Group 2

Expert sheet: Triangles and other polygons

Content

i. The sum of the angles of a triangle is 2 right angles.

ii. The exterior angle of a triangle equals the sum of the two interior opposite angles.

iii. Congruent triangles.

iv. Properties of special triangles – isosceles, equilateral, right-angled.

v. Properties of special quadrilaterals – parallelogram, rhombus, rectangle, square, trapezium.

vi. The sum of the angles of a polygon.

vii. Parallelograms on the same base and between the same parallels are equal in area.

Expert Group 3

Expert sheet: Circles

Content

i. Chords

ii. The angle which an arc of a circle subtends at the centre is twice that which it subtends at any point on the remaining part of the circumference.

iii. Any angle subtended at the circumference by a diameter is a right angle.

iv. Angles in the same segment are equal

v. Angles in opposite segments are supplementary.

Expert group 4

Expert sheet: Loci

Content

i. Bisectors of angles and line segments.

ii. Line parallel or perpendicular to a given line.

iii. An angle of 90º, 60º, 45º, 30º and an angle equal to a given angle.

iv. Triangles and quadrilaterals from sufficient data.

Appendix 4

JIGSAW IV LEARNING STRATEGY TEACHING AND TRAINING MANUAL

Purpose of the Manual

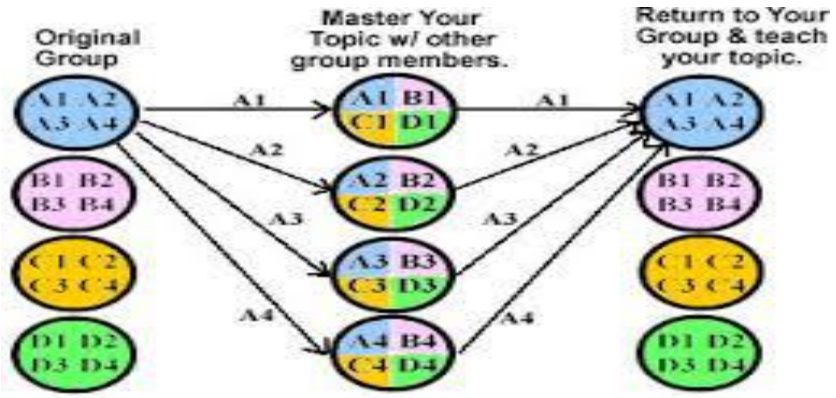
The purpose of this manual is to orient and acquaint research assistant (mathematics teachers) used in this study on the implement of the Jigsaw IV Learning Strategy (J4LS) in the teaching and learning of geometry. The J4LS like the other Jigsaws (Jigsaw I, II & III) is a student-centered learning strategy that facilitates learners' participation in the learning process and making learning more interesting to students and can be used to cover a large amount of material quickly.

Aim of the Manual

The aim of this manual is to minimize variability among teachers and the effect of other extraneous variable when J4CLS is used in the teaching of geometry.

What is the Jigsaw IV Learning Strategy (J4LS)

J4LS is a cooperative learning strategy developed by Holliday (2002) from Jigsaw III. In J4LS, learners (class) are split into small groups called home groups (HG). Each learner in the HG is expected to learn only part of a material in another group called the Expert Group (EG) which makes them experts (master in an area) in a part of the whole Jigsaw. The EG's go back to their HGs to teach and discuss their findings with their colleagues. The illustration of the J4LS is given in figure 1 below.



Jigsaw IV Learning Strategy Procedure

There are nine (9) steps in the J4LS procedure as postulated by Holliday (2002). They are as follows:

i. Introduction to the lesson

ii. Expert sheets assigned to expert group

iii. Groups answer expert questions prior to returning to home group

iv. Quiz on material in the expert group groups checking for accuracy

v. Students return to home groups sharing information with teammates

vi. Quiz on material shared checking for accuracy

vii. Review process. Whole group by Jeopardy, Quiz Bowl etc.

viii. Individual assessment and grading

ix. Re-teach any material missed on assessment as needed.

The Role of the Teacher in J4LS

According to Mbacho (2013) the following are the role of the teacher in the Jigsaw Class environment:

i. The teacher divides the students into groups which should be diverse of gender and ability. These are the initial groups called the Home Groups (HG).

ii. Then, the teacher appoints one person from each group as a leader who should be the most mature in the group. Also he/she divides the lesson into tasks and writes them into

the blackboard.

iii. He/ she gives each student in each group a number in form of a code. Students with the same code from each HG are assigned the same task and so on.

iv. The teacher ensures that students from each jigsaw group join other students assigned the same task to form "Expert Groups" (EG). The teacher gives the expert groups time to discuss their task and also refer from the text books and use resources available to complete the given task.

v. At completion of the above task, the teacher brings the students back to their jigsaw groups and asks each student to present his or her task to the group. The teacher floats from group to group observing the process.

vi. The teacher then, evaluates the lesson by either asking questions or giving an assignment on what has been learnt. In the case of this research, an individual assessment will be taken.

Instructional Objectives of J4LS

An instructional objective refers to the end results achievable in a lesson stated in the terms of changes of learner's behaviour. Behaviour includes mental (cognitive), emotional (effective) and physical (psychomotor) reactions. Instructional objectives should be stated in terms of learning outcomes because we are concerned with the products of learning rather than with the process of learning.

Instructional objectives provide directions to the teaching process, set the stage for evaluation of the student s learning. They are classified into three domains: cognitive, affective and psychomotor domains.

Cognitive domain

Objectives in cognitive domain relate to the intellectual abilities and skills. The objectives in this domain can be grouped into six major classes:

i. **Knowledge** – the objectives measures recall with the use of words like: list, state, etc.

ii. **Comprehension** - the objectives measures understanding with the use of the words: classify, convert, describe, explain, etc.

iii. **Application** - the objectives measures application to other situations with the use of the words: apply, using, compute, etc.

iv. **Analysis** - the objectives uses the words: analyses, differentiate, compare, and contrast.

v. **Synthesis**- the objectives uses the words such as compose, arrange, etc.

vi. **Evaluation**- the objectives uses the words such as assess, evaluate, criticize, appraise and others.

Affective Domain

The affective domain relates to attitudes, interests, believes and values. Objectives stated in this area are beginning to appear more frequently in the curriculum because they relate to issues and topics that are meaningful to young people such as drugs, HIV/AIDS, Pollution etc. Five major classes of effective domain are:

i. **Receiving** – the objectives uses the words such as choose, listen, etc.

ii. **Responding** - the objectives uses the words such as discuss, report, etc.

iii. **Valuing** - the objectives uses the words such as accept, argue about it, complete, etc.

iv. **Organization** - the objectives uses the words such as organize, relate, and modify.

v. Characterization by value - the objectives uses the words such as propose, oppose, and verify.

Psychomotor domain

Objectives in psychomotor reflects motor skills and hard eye conditions. They have a place in teaching of science especially in the laboratory. The terms used in writing objective in this area include: build, construct, calibrate, display, measure, etc.

Objectives in this domain are grouped into six classes;

i. Reflex Action

ii. **Perception abilities**- interprets various stimulus.

iii. **Physical abilities**- physical strength and stamina required for sustained effort.

iv. **Skilled movements**- refers to efficiency and skills in performing complex tasks e.g. swimming, driving.

v. **Non- discursive communication**- communication without producing sound (gesture, facial expression).

vi. **Basic fundamental movement**- these are walking, gr ipping, finger manipulation.

Expert Group 1: Instructional Objectives

Topic: Geometric Ratios

By the end of the topic, the learner should be able to:

1. Recall and apply the following theorems:
   i. State the equal intercept theorem
   ii. State the midpoint theorem
   iii. State the angle bisector theorem
2. Apply the above theorems to:
   i. division of line segments.
   ii. proportional divisions of the sides of a triangle.
   iii. ratio in geometrical figures.

Content

i. equal intercept
ii. midpoint theorem
iii. angle bisector theorem
iv. similar triangles

Resources

i. New General mathematics for Senior Secondary Schools Book 2, pg 56 – 66.
ii. Charts illustrating theorems
iii. Mathematical sets

Expert Group 2: Instructional Objectives

Topic: Triangles and polygons

By the end of the topic, the learner should be able to:

1. Recall and prove elementary theorems in plane geometry:

i. The exterior angle of a triangle is equal to the sum of the opposite interior angles
ii. The sum of an n-sided convex polygon is (2n-4) right angles
iii. The sum of the exterior angles of a convex polygon is 4 right angles.
iv.

2. Recall and apply the conditions for triangles to be congruent:

i. Two sides and the included angle
ii. Two angles and a corresponding side
iii. Three sides
iv. Right angle, hypotenuse and side

3. Use elementary theorems and properties of congruent triangles to prove theorems

4. Use and apply the equal and intercept theorem

Resources

i. New General mathematics for Senior Secondary Schools Book 1, pg 29 – 42.
ii. Cardboard, paper, scissors
iii. Mathematical sets

Expert Group 3: Instructional Objectives

Topic: Circles Geometry

By the end of the topic, the learner should be able to:

1. Recall, use and apply the mid-point properties of a chord
2. Recall, use and apply the following properties of angles subtended by arcs and chords at the centre and circumference of a circle;
    i. Angle at centre = 2x angle at circumference.
    ii. Angles in the same segment are equal
    iii. Angle in a semicircle = 90^o.
3. Recall, use and apply the following properties of cyclic quadrilaterals:
    i. Opposite angles are supplementary
    ii. Exterior angles = opposite interior angle.

Resources

i. New General mathematics for Senior Secondary Schools Book 2, pg 25 – 44.
ii. Cardboard models, paper, scissors
iii. Mathematical sets

Expert Group 4: Instructional Objectives

Topic: Constructions and Loci

By the end of the topic, the learner should be able to:

1. Define locus
2. Define and construct the locus of points which are
    i. A given distance from a fixed point
    ii. A given distance from a straight line
    iii. Equidistance from two given points
    iv. Equidistance from two given straight lines

3. Recall, use and apply the above constructions to solving locus problems

Resources

i. New General mathematics for Senior Secondary Schools Book 1, pg 193 – 203.
ii. Cardboard models, paper,
iii. Mathematical sets

Appendix 5

Geometry Performance Test Scores (Pretest)

GSS Dakachi		GSS T/ Jukun		GSS K/ Kuyanbana		GSS Aminu SNR	
10	5	20	10	40	10	15	10
5	6	5	10	10	30	15	10
10	5	10	10	5	10	20	10
6	5	15	10	6	10	6	35
8	5	10	10	8	30	10	10
10	5	10	10	10	10	10	15
5	10	10	10	20	10	15	0
5		18		10		20	
10		5		10		10	
6		10		10		10	
8		10		10		30	
10		10		10		20	
5		10		5		5	
10		10		8		10	
10		10		30		15	
15		10		10		10	
15		10		10		10	
20		5		10		10	
15		6		10		18	
8		8		15		5	
15		10		5		10	
6		10		6		15	
6		10		8		10	
6		10		10		20	
10		10		10		10	
5		10		10		10	
6		10		5		10	
5		15		10		25	
6		10		10		5	
8		15		30		13	
6		15		10		8	
6		20		10		10	
5		6		10		10	

Appendix 6

Geometry Performance Test Scores (Posttest)

Post GPT Experimental Group Scores		Post GPT Control Group Scores		Male/Female GPT Scores for Experimental Group			
63	58	35	48	75	Male	80	Male
65	63	30	65	60	Male	85	Male
55	76	40	70	50	Male	88	Male
50	65	57	33	40	Male	70	Male
60	68	20	35	70	Male	63	Female
65	60	25	38	58	Male	65	Female
75	85	38	25	63	Male	55	Female
70	80	45	25	76	Male	50	Female
70	73	35	45	65	Male	60	Female
63	55	30	45	68	Male	65	Female
63	65	33	25	60	Male	75	Female
68	90	30	35	85	Male	70	Female
60	75	30	40	80	Male	70	Female
70	55	33	25	73	Male	63	Female
75	55	33	35	55	Male	63	Female
55	60	40	40	65	Male	68	Female
48	65	50	35	90	Male	60	Female
52	30	20	45	75	Male	70	Female
63	43	23	35	55	Male	75	Female
78	60	40	23	55	Male	55	Female
58	60	23	45	60	Male	48	Female
80	60	38	35	65	Male	52	Female
90	68	18	33	30	Male	63	Female
63	63	45	28	43	Male	78	Female
50	65	33	35	60	Male	58	Female
55	70	35	38	60	Male	80	Female
63	73	43	35	60	Male	90	Female
60	75	50	33	68	Male	63	Female
68	78	53	40	63	Male	50	Female
83	68	40	40	65	Male	55	Female
80	65	30	65	70	Male	63	Female
70	80	18	45	73	Male	60	Female
75	85	23	23	75	Male	68	Female
60	88	38	40	78	Male	83	Female
50	70	43	25	68	Male	80	Female
40	70	45	35	65	Male	70	Female

Appendix 7

Geometry Interest Inventory score

Pre Exp. GII		Pre Control GII		Post Control GII		Post Exp. GII	
28	36	36	36	44	41	50	65
44	47	34	41	44	47	55	60
46	45	31	40	46	45	65	65
25	22	36	41	45	50	83	75
38	49	41	39	45	49	72	58
45	42	40	38	45	42	58	63
40	46	41	32	40	46	95	84
47	35	39	37	47	38	54	85
25	46	38	44	50	46	68	68
34	47	32	44	56	47	55	76
44	45	37	40	44	45	68	55
36	48	44	43	45	48	85	75
47	37	44	36	47	48	82	53
45	22	40	33	45	40	63	76
25	36	43	42	50	40	74	58
23	47	36	41	49	47	74	50
42	31	33	37	42	40	86	50
22	43	42	44	46	43	50	50
35	45	41	36	45	45	72	75
40	22	37	35	46	45	60	75
41	38	44	43	47	42	60	60
45	44	36	42	45	44	60	60
35	22	35	44	48	40	75	60
37	46	43	46	40	46	55	85
33	48	42	26	40	48	55	68
30	34	44	32	43	44	85	65
47	42	46	38	47	42	92	65
25	36	26	31	50	48	88	85
24	46	32	19	43	46	87	90
46	45	38	30	46	45	82	80
22	22	31	32	46	49	85	68
40	49	19	38	40	49	58	65
33	42	30	33	42	42	55	70
45	44	32	39	45	44	60	65
32		38		42		65	
27		36		50		60	
34		34		41		70	
44		31		44		65	

Appendix8

Jigsaw IV Cooperative Strategy Lesson Procedures

Expert Group 1 (Experimental Group): Lesson One

Subject: Mathematics
Topic: Geometry: Angles and Polygons
Class: Senior Secondary year two (SS2)
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:

Recall and prove the following elementary theorems:

i. The angle sum of an n-sided convex polygon is (2n-4) right angles.
ii. The sum of the exterior angles of a convex polygon is 4 right angles

Previous Knowledge: the students have been taught geometric figures like triangles and quadrilaterals in their previous classes. They have also been taught two important elementary proofs:

i. The angle sum of a triangle is 180^o
ii. the exterior angle of a triangle is equal to the sum of the opposite interior angles

Instructional materials: cardboard paper, scissors, mathematical sets. New General mathematics (NGM) for SS1

Introduction

The teacher introduces the lesson by giving a little talk on the meaning of convex, interior and exterior angles. Also brief talk is given on angles, polygons, proofs and their importance in mathematics. The other steps in the Jigsaw IV procedure follow this

Step 1: This has already been done; this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:

Theorems:

i. The angle sum of an n-sided convex polygon is (2n-4) right angles.
ii. The sum of the exterior angles of a convex polygon is 4 right angles

They are to use the book New General Mathematics (NGM) for SS1 page 30 - 32
Step 3: The group answers exercise 2a (NGM SS1, pg 32)
Step 4: quiz is giving from exercise 2a (NGM SS1, pg 32)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 1from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 1 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 1 (Experimental Group): Lesson Two

Subject: Mathematics
Topic: Geometry: Congruent Triangles
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:

Recall and apply the conditions for triangles to be congruent:

i. Two sides and the included angle
ii. Two angles and the included side
iii. Three sides
iv. Right angle, hypotenuse and side

Use the conditions in isosceles and equivalent triangles

Previous Knowledge: the students have been taught geometric figures like triangles and quadrilaterals in their previous classes.
Instructional materials: cardboard paper, scissors, mathematical sets. New General mathematics (NGM) for SS1

Introduction

The teacher introduces the lesson by giving a little talk on the meaning of congruency in relation to triangles. This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:

Recall and apply the conditions for triangles to be congruent:

i. Two sides and the included angle (SAS)
ii. Two angles and the included side (AAS or ASA)
iii. Three sides (SSS)
iv. Right angle, hypotenuse and Side (RHS)

Use the conditions in isosceles and equivalent triangles

They are to use the book New General Mathematics (NGM) for SS1 page 32 - 35
Step 3: The group answers exercise 2b and 2c (NGM SS1, pg 32- 35)
Step 4: quiz is giving from exercise 2b and 2c (NGM SS1, pg 32- 35)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 2 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 1 (Experimental Group): Lesson Three

Subject: Mathematics
Topic: Geometry: Parallelograms
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:

Use the elementary theorems and properties of congruent triangles to proof the following theorems:

i. The diagonals of a parallelogram bisects one another.
ii. In a parallelogram,
the opposite sides are equal
the opposite angles are equal

Previous Knowledge: the students were taught congruent triangles in their last class.
Instructional materials: cardboard paper, scissors, mathematical sets. New General mathematics (NGM) for SS1

Introduction

The teacher introduces the lesson by giving a brief talk on quadrilaterals (parallelograms, rhombus and rectangles). This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:

i. The diagonals of a parallelogram bisects one another.
ii. In a parallelogram,
the opposite sides are equal
the opposite angles are equal

They are to use the book New General Mathematics (NGM) for SS1 page 38 - 40
Step 3: The group answers exercise 2d and 2e (NGM SS1, pg 38 - 40)
Step 4: quiz is giving from exercise 2d and 2e (NGM SS1, pg 38 - 40)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 2from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 3 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 2 (Experimental Group): Lesson One

Subject: Mathematics
Topic: Geometry: Geometric Ratios
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:

1. Recall and apply the equal intercept theorem.
2. Apply the theorems to:
   i. Divisions of line segment
   ii. Proportional division of the sides of a triangle
   iii. Ratios in geometrical figures

Previous Knowledge: the students were taught introductory geometrical ratios in their previous class.They are also used to drawing lines and geometrical figures like triangles and parallelograms, angles, transversal, alternate and corresponding angles.
Instructional materials: Ruler,cardboard paper/ plane paper, scissors, mathematical sets, flash cards and relevant posters of geometric figures. New General mathematics (NGM) for SS2

Introduction

The teacher introduces the lesson by asking questions on the concept of intercept. Next, the teacher talks on the concept shedding more light and then talks about the theorem. This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:

Equal intercept
Equal intercept theorem and proof
How to a straight line into equal parts

They are to use the book New General Mathematics (NGM) for SS2 page 56 - 59
Step 3: The group answers exercise 6a and 6b (NGM SS2, pg 56 - 59)
Step 4: quiz is giving from exercise 6a and 6b (NGM SS2, pg 56 - 59)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 1 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 2 (Experimental Group): Lesson Two

Subject: Mathematics
Topic: Geometry: Geometric Ratios
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:

1. Recall and apply the mid-point theorem.

Previous Knowledge: the students were taught introductory geometrical ratios in their previous class.They are also used to drawing lines and geometrical figures like triangles and parallelograms, angles, transversal, alternate and corresponding angles.
Instructional materials: Ruler,cardboard paper/ plane paper, scissors, mathematical sets, flash cards and relevant posters of geometric figures. New General mathematics (NGM) for SS2
Introduction
The teacher introduces the lesson by asking questions on the concept of intercept. Next, the teacher talks on the concept shedding more light and then talks about the theorem. This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:

i. Mid-point concept
ii. Mid-point theorem and proof

They are to use the book New General Mathematics (NGM) for SS2 page 59 - 60
Step 3: The group answers exercise 6c (NGM SS2, pg 59 - 60)
Step 4: quiz is giving from exercise 6c (NGM SS2, pg 59 - 60)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 2 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 2 (Experimental Group): Lesson Three

Subject: Mathematics
Topic: Geometry: Bisector of an angle in triangle
Class: Senior Secondary year two (SS2)

Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:
Recall and apply the bisector theorem.
Previous Knowledge: the students were taught introductory geometrical ratios in their previous class.They are also used to drawing lines and geometrical figures like triangles and parallelograms, angles, transversal, alternate and corresponding angles.
Instructional materials: Ruler,cardboard paper/ plane paper, scissors, mathematical sets, flash cards and relevant posters of geometric figures. New General mathematics (NGM) for SS2
Introduction
The teacher introduces the lesson by asking questions on the concept of intercept. Next, the teacher talks on the concept shedding more light and then talks about the theorem. This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:

i. Bisector concept
ii. Bisector theorem and proof
iii. Similar triangles

They are to use the book New General Mathematics (NGM) for SS2 page 61 - 63
Step 3: The group answers exercise 6c (NGM SS2, pg 61 - 63)
Step 4: quiz is giving from exercise 6c (NGM SS2, pg 61 - 63)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 3 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 3 (Experimental Group): Lesson One
Subject: Mathematics
Topic: Circle Geometry: Chords, Arcs and Angles
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years

Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:

1. Define and name the lines regions of a circle including cyclic quadrilaterals
2. Recall, use and apply the mid-point properties of a chord.

Previous Knowledge: The students were taught introductory circle geometry in their previous class.They were also taught concept of and mid-point theorem in their last lesson
Instructional Material: Mathematical set (Protractor and compasses), models of circle geometrical figures on cardboard, plane papers etc. New General mathematics (NGM) for SS2
Introduction
The teacher introduces the lesson by asking questions on the concept of mid-point and its theorem in relation to triangles earlier learnt. Next, the teacher talks generally on the lines and regions of a circle and a cyclic quadrilaterals. This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:
Definitions of chord, diameter, major and minor arcs and their diagrammatic representations
Define and name major and minor segment of a circle
Angles in major and minor segment of a circle
Mid-point of a chord and mid-point theorem
They are to use the book New General Mathematics (NGM) for SS2 page 25 - 26
Step 3: The group answers exercise 2a (NGM SS2, pg 25 - 26)
Step 4: quiz is giving from exercise 2a (NGM SS2, pg 25 - 26)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 1 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 3 (Experimental Group): Lesson Two

Subject: Mathematics
Topic: Circle Geometry: Chords, Arcs and Angles II
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:
Recall, use and apply the following properties of angles subtended arcs and chords at the center and circumference of a circle.

i. Angle at the center = 2x angle at circumference
ii. Angles in the same segment are equal
iii. Angle in a semicircle = 90^o

Previous Knowledge: The students were taught introductory circle geometry in their previous class.They were also taught concept of and mid-point theorem in their last lesson
Instructional Material: Mathematical set (Protractor and compasses), models of circle geometrical figures on cardboard, plane papers etc. New General mathematics (NGM) for SS2
Introduction
The teacher introduces the lesson by asking questions on the concept of mid-point and its theorem in relation to triangles earlier learnt. Next, the teacher talks generally on the lines and regions of a circle and a cyclic quadrilaterals. This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:
Theorems on:

i. Angle at the center = 2x angle at circumference
ii. Angles in the same segment are equal
iii. Angle in a semicircle = 90^o

They are to use the book New General Mathematics (NGM) for SS2 page 27 - 30
Step 3: The group answers exercise 2b and 2c (NGM SS2, pg 27 - 30)
Step 4: quiz is giving from exercise 2b and 2c (NGM SS2, pg 27 - 30)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 2 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 3 (Experimental Group): Lesson Two

Subject: Mathematics
Topic: Circle Geometry: Chords, Arcs and Angles III
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:
Recall, use and apply the following properties of cyclic quadrilaterals

1. Opposite angles are supplementary
2. Exterior angles = opposite interior angle

Previous Knowledge: The students were taught introductory circle geometry in their previous class.They were also taught the theorems:

i. Angle at the center = 2x angle at circumference
ii. Angles in the same segment are equal
iii. Angle in a semicircle = 90^o

Instructional Material: Mathematical set (Protractor and compasses), models of circle geometrical figures on cardboard, plane papers etc. New General mathematics (NGM) for SS2

Introduction

The teacher introduces the lesson by asking questions on the concept of mid-point and its theorem in relation to triangles earlier learnt. Next, the teacher talks generally on the lines and regions of a circle and a cyclic quadrilaterals. This is followed by the other steps in the Jigsaw IV procedure

Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:
Theorems on:
Recall, use and apply the following properties of cyclic quadrilaterals

1. Opposite angles are supplementary and proof
2. Exterior angles = opposite interior angle; and proof

They are to use the book New General Mathematics (NGM) for SS2 page 30 - 34
Step 3: The group answers exercise 2d (NGM SS2, pg 30 - 34)
Step 4: quiz is giving from exercise 2d (NGM SS2, pg 30 - 34)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 2 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 4 (Experimental Group): Lesson Two

Subject: Mathematics
Topic: Loci: Construction and Locus
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:

1. Construct triangles and quadrilaterals involving
    a. Bisecting a giving line segment
    b. Bisecting any angle
2. Construction of special angles (90^o, 45^o, 60^o, 30^o, 15^o)
3. Construction of combination angles (75^o, 105^o, 135^o, etc)

Previous Knowledge: The students were taught introductory construction in their previous class.
Instructional Material: Mathematical set, models of constructed geometrical of special and combination angles, plane papers. New General mathematics (NGM) for SS1
Introduction
The teacher introduces the lesson by giving a brief talk on construction, bisection of line segment and angles learnt in previous classes. This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:

1. Construct triangles and quadrilaterals involving
    a. Bisecting a giving line segment
    b. Bisecting any angle
2. Basic construction of special angles (90^o, 45^o, 60^o, 30^o, 15^o)
3. Basic construction of combination angles (75^o, 105^o, 135^o, etc)

They are to use the book New General Mathematics (NGM) for SS1 page 193 - 196
Step 3: The group answers exercise 16a and 16b (NGM SS1, pg 193 - 196)
Step 4: quiz is giving from exercise 16a and 16b (NGM SS1, pg 193 - 196)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 2 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Jigsaw IV Cooperative Strategy Lesson Procedures

Expert Group 4 (Experimental Group): Lesson Two

Subject: Mathematics
Topic: Loci: Construction and Locus II
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:

Construct triangles and quadrilaterals involving:

i. special angles (90^o, 45^o, 60^o, 30^o, 15^o)
ii. combination angles (75^o, 105^o, 135^o, etc)

Previous Knowledge: The students were taught construction of special angles (90^o, 45^o, 60^o, 30^o, 15^o) and combination angles (75^o, 105^o, 135^o, etc) in their previous class.They have also learnt how to construct geometrical figures like triangle quadrilaterals in their previous classes.
Instructional Material: Mathematical set, models of constructed geometrical of special and combination angles, plane papers. New General mathematics (NGM) for SS1
Introduction
The teacher introduces the lesson by giving a brief talk on special and combination angles. This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:

Construct triangles and quadrilaterals involving:

iii. special angles (90^o, 45^o, 60^o, 30^o, 15^o)
iv. combination angles (75^o, 105^o, 135^o, etc)

They are to use the book New General Mathematics (NGM) for SS1 page 196 - 197
Step 3: The group answers exercise 16a and 16b (NGM SS1, pg 196 - 197)
Step 4: quiz is giving from exercise 16a and 16b (NGM SS1, pg 196 - 197)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 2 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.
Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Expert Group 4 (Experimental Group): Lesson Three

Subject: Mathematics
Topic: Loci: Construction and Locus III
Class: Senior Secondary year two (SS2)
Class Ability: Average
Class Ability: Average
Average Age:17 years
Sex: Male and Female
Number in Class:72
Duration:70 minutes
Behavioural Objectives: By the end of the lesson, the students should be able to:

1. Define locus
2. Construct the locus of points that are:

i. A given distance from a fixed point
ii. A given distance from a straight line
iii. Equidistance from a straight line
iv. Equidistance from two given points
v. Equidistance from two given straight lines

Previous Knowledge: The students have been taught construction in their previous class.They have also learnt how to construct geometrical figures like triangle quadrilaterals in their previous classes.
Instructional Material: Mathematical set, models of constructed geometrical of special and combination angles, plane papers.
Introduction
The teacher introduces the lesson by giving a brief talk on loci and its importance in mathematics. This is followed by the other steps in the Jigsaw IV procedure
Step 1: This has already been done this is expert group 1
Step 2: The students are given their expert sheet which contains what they are expected to master:

1. Define locus
2. Construct the locus of points that are:
   i. A given distance from a fixed point
   ii. A given distance from a straight line
   iii. Equidistance from a straight line
   iv. Equidistance from two given points
   v. Equidistance from two given straight lines

They are to use the book New General Mathematics (NGM) for SS1 page 198 - 203
Step 3: The group answers exercise 16c and 16d (NGM SS1, pg 198 - 203)
Step 4: quiz is giving from exercise 16c and 16d (NGM SS1, pg 198 - 203)
Step 5: Members return to their Home Group (HG) for interactions
Step 6: The whole class are quizzed based on lesson 2 from their various expert groups (Expert group 1- 4)
Step 7: The teacher does a general review of the four lessons (lesson 2 from the four expert groups)
Step 8: The teacher does this in the concluding week of treatment.

Step 9: The teacher does this in the concluding week of treatment.
Step 10: Conclusion is question and answer sessions

Appendix 9

Control Group (Lecture Method): Lesson Plans

Control Group:

Lesson One

Subject: Mathematics

Topic: Geometry: Angles and Polygons

Class: Senior Secondary year two (SS2)

Class Ability: Average

Average Age:17 years

Sex: Male and Female

Number in Class:72

Duration: 45 minutes

Behavioural Objectives: By the end of the lesson, the students should be able to:

Recall and prove the following elementary theorems:

iii. The angle sum of an n-sided convex polygon is (2n-4) right angles.

iv. The sum of the exterior angles of a convex polygon is 4 right angles

Previous Knowledge: the students have been taught geometric figures like triangles and quadrilaterals in their previous classes. They have also been taught two important elementary proofs:

iii. The angle sum of a triangle is 180^{o}

iv. the exterior angle of a triangle is equal to the sum of the opposite interior angles

Instructional materials: cardboard paper, scissors, mathematical sets. New General mathematics (NGM) for SS1

Introduction

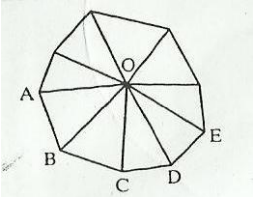
The teacher introduces the lesson by asking the students a few questions about proofs earlier learnt: angle sum of a triangle, exterior angle of a triangle is equal to sum of the opposite interior angles.

Presentation: The teacher presents the lesson by the following steps.

Step 1: The teacher writes the theorem to be learnt on the chalkboard, reads it to the hearing of the students and ask them to repeat after him.

Theorem: The sum of the interior angle of an n-sided convex polygon is (2n-4) right angles.

Step 2: The teacher explains the theorem by drawing a diagram



Step 3: The teacher proceeds with the proof explaining every line of it.

Given: any convex polygon* ABCDE … with n sides.

To prove: $\widehat{A} + \widehat{B} + \widehat{C} + \ldots = (2n - 4)$ right angles.

Construction: Join the vertices A, B, C, … to any point O inside the polygon.

Proof:

By construction there are n triangles. (*Polygon ABCDE … has n sides.*)

Sum of angles of 1 $\triangle = 180°$ or 2 right angles

$\therefore$ Sum of angles of n $\triangle$s $= 2n$ right angles

Sum of angles at O $= 360°$ or 4 right angles

(*sum of angles at a point = 360°*)

Sum of angles of polygon ABCDE …

= Sum of angles of n $\triangle$s − sum of angles at O

$\therefore$ $\widehat{A} + \widehat{B} + \widehat{C} + \ldots = (2n - 4)$ right angles

Step 4: The teacher goes over the proof again and ensures students understand.

Step 5: The teacher asks the students to copy the theorem and proof from the chalkboard.

Evaluation: The teacher asks the students to state the theorem by heart and explain the proof.

Conclusion: The teacher concludes the lesson by asking students to write down the proof without looking at their books or the chalkboard.

Lesson Two

Subject: Mathematics

Topic: Geometry: Angles and Polygons

Class: Senior Secondary year two (SS2)

Class Ability: Average

Average Age:17 years

Sex: Male and Female

Number in Class:72

Duration: 45 minutes

Behavioural Objectives: By the end of the lesson, the students should be able to:

Recall and prove the following elementary theorems:

v. The angle sum of an n-sided convex polygon is (2n-4) right angles.

vi. The sum of the exterior angles of a convex polygon is 4 right angles

Previous Knowledge: the students have been taught geometric figures like triangles and quadrilaterals in their previous classes. They have also been taught two important elementary proofs:

i. The angle sum of a triangle is 180^{o}

ii. The exterior angle of a triangle is equal to the sum of the opposite interior angles

Instructional materials: cardboard paper, scissors, mathematical sets. New General mathematics (NGM) for SS1

Introduction

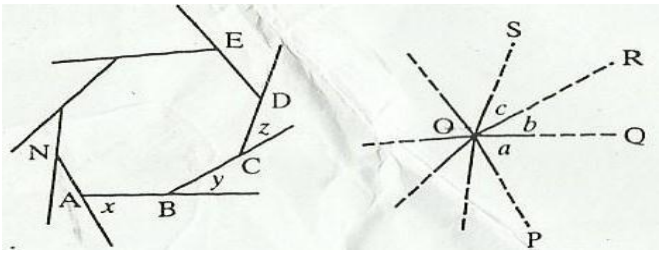
The teacher introduces the lesson by asking the students a few questions about proofs earlier learnt: angle sum of a triangle, exterior angle of a triangle is equal to sum of the opposite interior angles.

Presentation: The teacher presents the lesson by the following steps.

Step 1: The teacher writes the theorem to be learnt on the chalkboard, reads it to the hearing of the students and ask them to repeat after him.

Theorem: The sum of the exterior angles of any convex polygon is 4 right angles.

Step 2: The teacher explains the theorem by drawing a diagram



Step 3: The teacher proceeds with the proof explaining every line of it.

Given: any convex polygon ABCDE … N with n sides, each side produced to give exterior angles $x, y, z, \ldots$

To prove: $x + y + z + \ldots = 4$ right angles.

Construction: From any point O, draw lines OP, OQ, OR, OS, … parallel to the sides of ABCDE … N in turn.

Proof:

With the lettering of the diagram,

$a = x$ ($OP \parallel \overline{NA}$ and $OQ \parallel \overline{AB}$)

Similarly, $b = y, c = z, \ldots$

But $a + b + c + \ldots = 4$ right angles

(*angles at a point*)

$\therefore \; x + y + z + \ldots = 4$ right angles

Step 4: The teacher goes over the proof again and ensures students understand.

Step 5: The teacher asks the students to copy the theorem and proof from the chalkboard.

Step 6: The teacher solves two problems as examples of the application of the theorems learnt in lesson one and two on the chalkboard.

Evaluation: The teacher asks the students to state the theorem by heart and explain the proof.

Conclusion: The teacher concludes the lesson by asking students to write down the proof without looking at their books or the chalkboard.

Lesson Three

Subject: Mathematics

Topic: Geometry: Congruent Triangles

Class: Senior Secondary year two (SS2)

Class Ability: Average

Class Ability: Average

Average Age:17 years

Sex: Male and Female

Number in Class:72

Duration:45minutes

Behavioural Objectives: By the end of the lesson, the students should be able to:

Recall and apply the conditions for triangles to be congruent:

v. Two sides and the included angle

vi. Two angles and the included side

vii. Three sides

viii. Right angle, hypotenuse and side

Use the conditions in isosceles and equivalent triangles

Previous Knowledge: the students have been taught geometric figures like triangles and quadrilaterals in their previous classes.

Instructional materials: cardboard paper, scissors, mathematical sets. New General mathematics (NGM) for SS1.

Presentation: The teacher presents the lesson by the following steps.

Step 1: The teacher writes the topic on the day on the chalkboard, reads it to the hearing of the students and ask them to repeat after him.

Step 2: The teacher explains what is meant by congruent. That is two figures are said to be congruent if they are exactly the same shape and size. He shows the class examples of the congruent triangles drawn on cardboard paper. He also gives the conditions for triangles to be congruent:

v. Two sides and the included angle (SAS)
vi. Two angles and the included side (AAS or ASA)
vii. Three sides (SSS)
viii. Right angle, hypotenuse and Side (RHS)

Step 3: The teacher shows the students how to name congruent triangles with regard to the conditions in step 2.

i. Side Angle Side (SAS)
ii. Angle Side Angle (ASA) or Angle Angle Side (AAS)
iii. Side Side Side (SSS)
iv. Right angled Hypotenuse Side (RHS) not Right Hand Side

Step 4: The teacher solves a few questions on the application of the conditions orally with student participating using models drawn on cardboard paper.

Evaluation: The teacher evaluates the lesson by asking students to state the conditions for congruency with regards to triangle and give examples.

Conclusion: The students were given some exercises to solve.

Lesson Four

Subject: Mathematics

Topic: Geometry: Parallelograms

Class: Senior Secondary year two (SS2)

Class Ability: Average

Class Ability: Average

Average Age:17 years

Sex: Male and Female

Number in Class:72

Duration:70 minutes

Behavioural Objectives: By the end of the lesson, the students should be able to:

Use the elementary theorems and properties of congruent triangles to proof the following theorems:

iii. The diagonals of a parallelogram bisects one another.

iv. In a parallelogram,
the opposite sides are equal
the opposite angles are equal

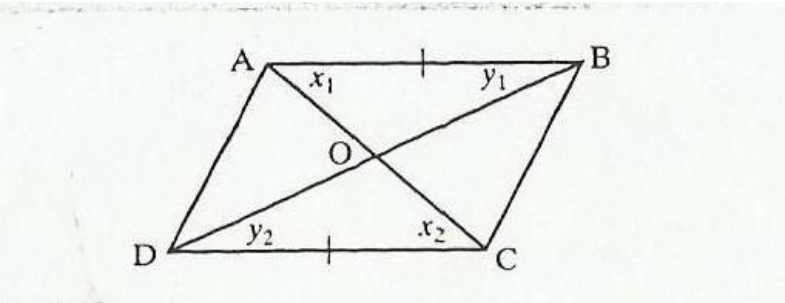
Previous Knowledge: the students were taught congruent triangles in their last class.

Instructional materials: cardboard paper, scissors, mathematical sets. New General mathematics (NGM) for SS1

Presentation: The teacher presents the lesson by the following steps.

Step 1: The teacher writes the topic on the day on the chalkboard, reads it to the hearing of the students and ask them to repeat after him. He also write the theorem on the chalkboard.

Step 2: The teacher explains the theorem by drawing a diagram



Step 3: The teacher proceeds with the proof explaining every line of it.

Given: parallelogram ABCD with diagonals $\overline{AC}$ and $\overline{BD}$ intersecting at O.

To prove: |AO| = |OC|, |BO| = |OD|.

Proof:

In △s AOB and COD,

	$x_1 = x_2$	(*alt. angles*, AB||CD)
	$y_1 = y_2$	(*alt. angles*, AB||CD)
	|AB| = |CD|	(*opp. sides of* $\|^{gm}$)
∴	△AOB ≡ △COD	(*ASA*)
∴	|AO| = |CO|	(*corresp. sides*)
and	|BO| = |DO|	(*corresp. sides*)

Evaluation: The teacher evaluates the lesson by going over the theorem and proof explains once more the areas students were identified to be weak at.

Conclusion: the teacher concludes the lesson by giving the following exercises to students to proof.

Give a formal proof of the following theorems:

1. A quadrilateral with one pair of opposite sides equal and parallel is a parallelogram.
2. The diagonals of a rhombus (i) bisects each other at right angles. (ii) bisects the angles of the rhombus.

Lesson Five

Subject: Mathematics

Topic: Geometry: Geometric Ratios

Class: Senior Secondary year two (SS2)

Class Ability: Average

Class Ability: Average

Average Age:17 years

Sex: Male and Female

Number in Class:72

Duration:45 minutes

Behavioural Objectives: By the end of the lesson, the students should be able to:

3. Recall and apply the equal intercept theorem.
4. Apply the theorems to:

iv. Divisions of line segment

v. Proportional division of the sides of a triangle

vi. Ratios in geometrical figures

Previous Knowledge: the students were taught introductory geometrical ratios in their previous class.They are also used to drawing lines and geometrical figures like triangles and parallelograms, angles, transversal, alternate and corresponding angles.

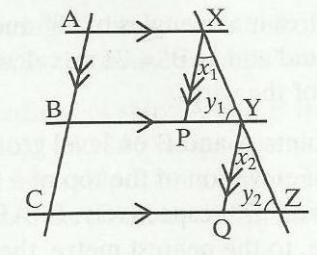
Instructional materials: Ruler,cardboard paper/ plane paper, scissors, mathematical sets, flash cards and relevant posters of geometric figures. New General mathematics (NGM) for SS2

Presentation: The teacher presents the lesson by the following steps.

Step 1: The teacher writes the topic on the day on the chalkboard, reads it to the hearing of the students and ask them to repeat after him. He also write the theorem on the chalkboard.

Step 2: The teacher explains the theorem by drawing a diagram

Theorem: If three or more parallel lines cut off equal intercept on a transversal, then they cut off equal intercepts on a transversal.



Step 3: The teacher proceeds with the proof explaining every line of it.

Given: Three parallel lines cutting a fourth line at A, B, C so that |AB| = |BC| and cutting another line at X, Y, Z respectively.

To prove: |XY| = |YZ|.

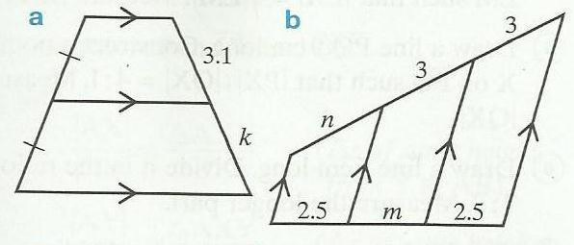
Construction: Draw $\overline{XP}$ and $\overline{YQ}$ parallel to $\overline{ABC}$ to cut $\overline{BY}$ and $\overline{CZ}$ at P and Q respectively.

Proof:

AXPB is a parallelogram	(*opp. sides* ‖)
$\therefore$ |XP| = |AB|	(*opp. side equal*)
Similarly |YQ| = |BC|	(*in* $\|\|^{gm}$ YQCB)
$\therefore$ |XP| = |YQ|	(*given* |AB| = |BC|)
In $\triangle$s XPY, YQZ	
|XP| = |YQ|	(*proved*)
$x_1 = x_2$	(*corr. angles*)
$y_1 = y_2$	(*corr. angles*)
$\therefore$ $\triangle$XPY $\equiv$ $\triangle$YQZ	(*AAS*)
$\therefore$ |XY| = |YZ|	

Step 4: The teacher goes over the proof again and ensures students understand. He also solves the following questions orally with the students participating.

Find the lettered lengths. All dimensions are in centimetres.



Step 5: The teacher asks the students to copy the theorem and proof from the chalkboard.

Evaluation: The teacher asks the students to state the theorem by heart and explain the proof.

Conclusion: The teacher concludes the lesson by asking students to write down the proof without looking at their books or the chalkboard.

Lesson Six

Subject: Mathematics

Topic: Geometry: Geometric Ratios

Class: Senior Secondary year two (SS2)

Class Ability: Average

Class Ability: Average

Average Age:17 years

Sex: Male and Female

Number in Class:72

Duration:70 minutes

Behavioural Objectives: By the end of the lesson, the students should be able to:

2. Recall and apply the mid-point theorem.

Previous Knowledge: the students were taught introductory geometrical ratios in their previous class.They are also used to drawing lines and geometrical figures like triangles and parallelograms, angles, transversal, alternate and corresponding angles.

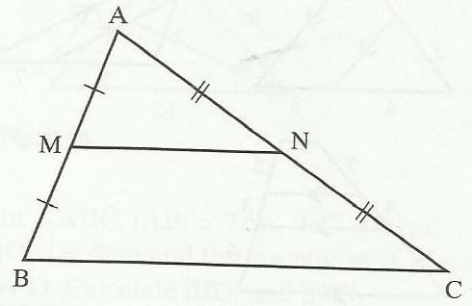
Instructional materials: Ruler,cardboard paper/ plane paper, scissors, mathematical sets, flash cards and relevant posters of geometric figures. New General mathematics (NGM) for SS2

Presentation: The teacher presents the lesson by the following steps.

Step 1: The teacher writes the topic on the day on the chalkboard, reads it to the hearing of the students and ask them to repeat after him. He also write the theorem on the chalkboard.

Step 2: The teacher explains the theorem by drawing a diagram

Theorem: The line joining the midpoints of two sides of a triangle is parallel to the third side and equal to half of it.



Step 3: The teacher proceeds with the proof explaining every line of it.

Given: $\triangle ABC$ with M, N the midpoints of AB, AC respectively.

To prove: $\overline{MN} \| \overline{BC}$ and $|MN| = \frac{1}{2}|BC|$.

Proof:

$$\frac{|AM|}{|MB|} = \frac{|AN|}{|NC|} = \frac{1}{1}$$ (M *and* N *are midpoints of* AB *and* AC)

It follows that $\overline{MN} \parallel \overline{BC}$ ($\overline{MN}$ *divides* $\overline{AB}$ *and* $\overline{AC}$ *in the same ratio – previous theorem*)

$\therefore$ $\triangle AMN$ is similar to $\triangle ABC$

$$\frac{|MN|}{|BC|} = \frac{|AM|}{|AB|} \qquad (\triangle AMN \,|||\, \triangle ABC)$$

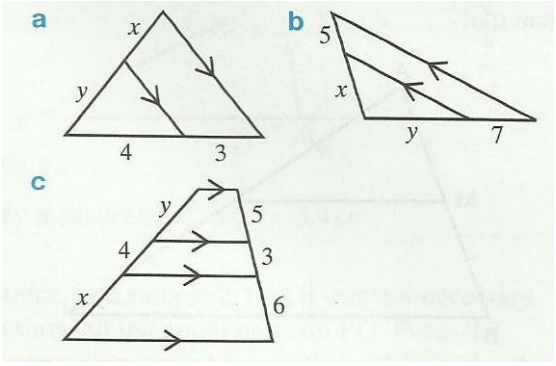
But $$\frac{|AM|}{|AB|} = \frac{1}{2} \qquad (\textit{given } |AM| = |MB|)$$

$\therefore$ $$\frac{|MN|}{|BC|} = \frac{1}{2}$$

or $$|MN| = \frac{1}{2}|BC|.$$

Step 4: The teacher goes over the proof again and ensures students understand. He also solves the following questions orally with the students participating.

State the value of the ratio x:y for each part of the figures a, b and c.



Step 5: The teacher asks the students to copy the theorem and proof from the chalkboard.

Evaluation: The teacher asks the students to state the theorem by heart and explain the proof.

Conclusion: The teacher concludes the lesson by asking students to write down the proof without looking at their books or the chalkboard.

Lesson Seven

Subject: Mathematics

Topic: Geometry: Bisector of an angle in triangle

Class: Senior Secondary year two (SS2)

Class Ability: Average

Class Ability: Average

Average Age:17 years

Sex: Male and Female

Number in Class:72

Duration: 45 minutes

Behavioural Objectives: By the end of the lesson, the students should be able to:

Recall and apply the bisector theorem.

Previous Knowledge: the students were taught introductory geometrical ratios in their previous class.They are also used to drawing lines and geometrical figures like triangles and parallelograms, angles, transversal, alternate and corresponding angles.

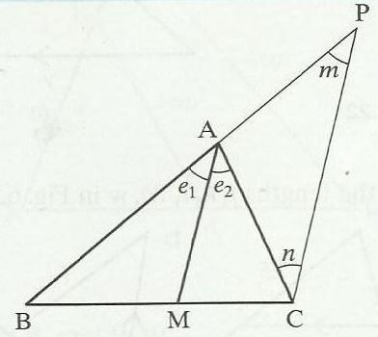
Instructional materials: Ruler,cardboard paper/ plane paper, scissors, mathematical sets, flash cards and relevant posters of geometric figures. New General mathematics (NGM) for SS2

Presentation: The teacher presents the lesson by the following steps.

Step 1: The teacher writes the topic on the day on the chalkboard, reads it to the hearing of the students and ask them to repeat after him. He also write the theorem on the chalkboard.

Step 2: The teacher explains the theorem by drawing a diagram

Theorem: The bisector of an angle in a triangle divides the opposite side in the ratio of the sides containing the angle.



Step 3: The teacher proceeds with the proof explaining every line of it.

Given: $\triangle ABC$ with $\overline{AM}$ bisecting $\hat{A}$ and meeting $\overline{BC}$ at M.

To prove: $\frac{|BA|}{|AC|} = \frac{|BM|}{|MC|}$

Construction: Draw $\overline{CP} \parallel \overline{MA}$, to cut $\overline{BA}$ produced at P.

Proof:

With the lettering used in Fig. 6.17,

$m = e_1$ (*corr. angles*)

$= e_2$ (*given* $e_1 = e_2$)

$= n$ (*alt. angles*)

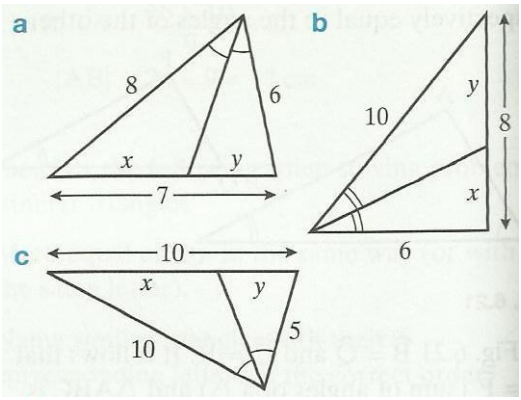
$\therefore$ $\triangle PAC$ is isosceles with $|AC| = |AP|$.

$\therefore \frac{|BA|}{|AC|} = \frac{|BA|}{|AP|}$

$\therefore \frac{|BA|}{|AC|} = \frac{|BM|}{|MC|}$ $(\overline{AM} \parallel \overline{PC})$

Step 4: The teacher goes over the proof again and ensures students understand. He also solves the following questions orally with the students participating.

Find the ratio x: y and the values of x and y in each of the figure below.



Step 5: The teacher asks the students to copy the theorem and proof from the chalkboard.

Evaluation: The teacher asks the students to state the theorem by heart and explain the proof.

Conclusion: The teacher concludes the lesson by asking students to write down the proof without looking at their books or the chalkboard.

Lesson Eight

Subject: Mathematics

Topic: Circle Geometry: Chords, Arcs and Angles

Class: Senior Secondary year two (SS2)

Class Ability: Average

Class Ability: Average

Average Age:45 years

Sex: Male and Female

Number in Class:72

Duration: 45 minutes

Behavioural Objectives: By the end of the lesson, the students should be able to:

3. Define and name the lines regions of a circle including cyclic quadrilaterals
4. Recall, use and apply the mid-point properties of a chord.

Previous Knowledge: The students were taught introductory circle geometry in their previous class.They were also taught concept of and mid-point theorem in their last lesson

Instructional Material: Mathematical set (Protractor and compasses), models of circle geometrical figures on cardboard, plane papers etc. New General mathematics (NGM) for SS2

Presentation: The teacher presents the lesson by the following steps.

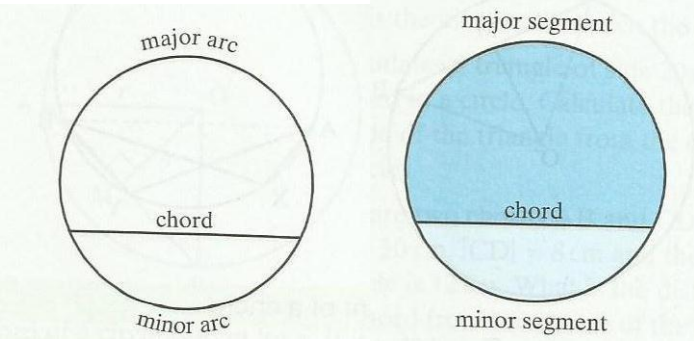
Step 1: The teacher writes the topic on the day on the chalkboard, reads it to the hearing of the students and ask them to repeat after him. He also write the theorem on the chalkboard. The teacher introduces the lesson by asking questions on the concept of mid-point and its theorem in relation to triangles earlier learnt.

Step 2: The teacher defines the following terms and uses a chart showing them so that students can see.

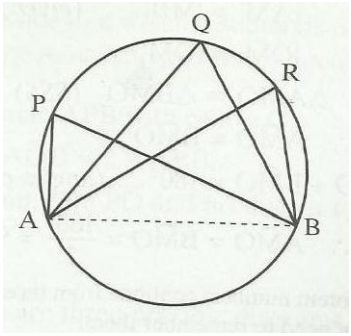
Chord of circle: this a line segment joining any two points on a circumference.

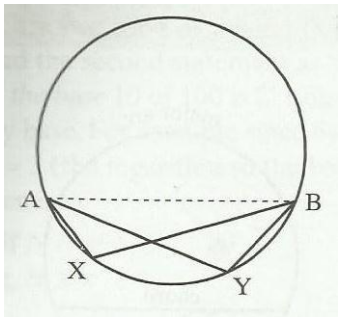
Diameter: this is a chord which passes through the center of a circle.

The teacher also shows the students with the aid of a diagram what a minor and major arc is. He also shows them with the aid of a diagram what a major and minor segment.



Step 4: At this point the teacher shows the students what is meant by angles subtended at the circumference by a chord, angles in a the same segment whether in a major or minor segment with the aid of the following diagrams:

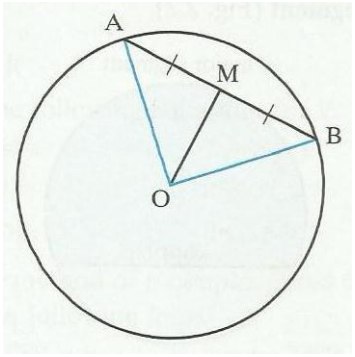




Step 5: Next the teacher introduces theorem on the mid-point of a chord.

Theorem: A straight line drawn from the centre of a circle to bisect a chord, which is not a diameter, is at right angles to the chord.

The teacher then proceeds with the proof explaining each line of it with the aid of the following diagram:



Given a circle with centre O and chord
OM such that **AM** = **MB**

To Prove: AMQ = BMQ = 90^o
Construction: Join OA and OB

Proof:
With the lettering in the diagram above,
OA = OB (radii)

AM = MB (given)

OM = OM

Therefore triangle AMQ = triangle BMQ (SSS)

Therefore triangle AMQ = triangle BMQ

But AMQ + BMQ = 180^o (angles on straight line)

Therefore AMQ = BMQ = $\frac{180^o}{2} = 90^o$

Step 6: The teacher makes the following observation for students to note:

1. A straight line drawn from the centre of a chord of a circle perpendicular to a chord bisects the chord and
2. The perpendicular bisector of a chord of a circle passes through the centre of the circle.

Evaluation: The teacher asks the students to state the theorem by heart and explain the proof.

Conclusion: The teacher concludes the lesson by asking students to write down the proof without looking at their books or the chalkboard. He also gives them take home exercises from NGM for SS2; exercise 2a questions 1- 6.

Appendix 10

DEPARTMENT OF SCIENCE EDUCATION
AHMADU BELLO UNIVERSITY ZARIA

Vice Chancellor: ***Professor Abdullahi Mustapha*** *B.Sc(Hons)Pharm(ABU), Ph.D(London) FPSN*
Head of Department: ***Dr. Mamman Musa*** *B.Ed, M.Ed, Ph.D (ABU, FMAN, FANE, DAC.*

Your Ref:
Our Ref: DSE/R/I/Vol.1 ***Date:*** 6th April, 2015

The Director,
Zaria Educational Zone
Ministry of Education
Zaria

Dear Sir/Madam,

AN INTRODUCTORY LETTER TO ACCESS RESEARCH DATA

This is to introduce the bearer, JOSEPH MAJIYEBO TIMAYI, with registration number M.ED/EDUC/5584/2011-12, as one of our POST-GRADUATE students who is conducting a research on the topic:

Effects of Jigsaw IV Cooperative Learning on Academic Performance and Interest of Secondary School Students in Geometry in Kaduna State, Nigeria

Please accept our sincere thanks in advance for your kind action.

Yours faithfully,

H. O. D.
Science Education
A. B. U. Zaria

Dr. Mamman Musa
Head, Science Education Department

Appendix 11

Kaduna State Ministry of Education,
Zonal Office Headquarters,
Zaria.
Date: 27/08/15

The Principal,
GSS Dakachi

LETTER OF INTRODUCTION

The bearer is
JOSEPH MAJIYEBO TIMAYI ..... in
the de of/from
Department of Science Edueatim ABU, Zaria ..... and
wish to conduct a research in the following areas;

1. Effects of Jigsaw IV Cooperative
2. Learning on Academic Performance
3. and Interest of Secondary School
4. Students in Geometry in Kaduna State
5. Nigeria

I am directed to request you to allow him/her the use of your facility accordingly please.

ZONAL EDUC. OFFICE
ZARIA
Yakubu Abubakar
PRSIG A
For: Director.

Appendix 12

Kaduna State Ministry of Education,
Zonal Office Headquarters,
Zaria.
Date: 27/08/15

The Principal,
GSS T/Hukum

LETTER OF INTRODUCTION

The bearer is
Joseph Majiyebo Timayi ..... in
the de of/from
Department of Science Education ABU, Zaria ..... and
wish to conduct a research in the following areas;

1. Effects of Jigsaw IV Cooperative Learning
2. on Academic Performance and Interest
3. of Secondary School Students in
4. Geometry in Kaduna State, Nigeria
5. .....

I am directed to request you to allow him/her the use of your facility accordingly please.

ZONAL EDUC. OFFICE ZARIA
Yakubu Abubakar
For: Director.

Appendix 13

Kaduna State Ministry of Education,
Zonal Office Headquarters,
Zaria.
Date: 27/08/15

The Principal,
GSS K/Kuyambana

LETTER OF INTRODUCTION

The bearer is
JOSEPH MAJIYEBO TIMAYI ..... in

the de of/from
Department of Science Education, ABU, Zaria ..... and

wish to conduct a research in the following areas;

1. Effects of Jigsaw IV Cooperative Learing
2. on Academic Performance and Intenst
3. of Secondary School Students in
4. Geometry in Kaduna State, Nigeria.
5. .....

I am directed to request you to allow him/her the use of your facility accordingly please.

ZONAL EDUC. OFFICE
Yakubu Abubakar
PRSI/A
For: Director.

Appendix 14

Kaduna State Ministry of Education,
Zonal Office Headquarters,
Zaria.
Date: 27/08/15

The Principal,
GSS Aminu (Snr)

LETTER OF INTRODUCTION

The bearer is
JOSEPH MAJIYEBO TIMAYI ..... in
the de of/from
Department of Science Education, ABU, Zaria ..... and
wish to conduct a research in the following areas;

1. Effects of Jigsaw IV Cooperative learning
2. on Academic Performance and Interest
3. of Secondary School Students in
4. Geometry in Kaduna State, Nigeria
5. .....

I am directed to request you to allow him/her the use of your facility accordingly please.

ZONAL EDUC. OFFICE ZARIA
Yakubu Abubakar
PRS/GA
For: Director.

Appendix 15

MINISTRY OF EDUCATION
KADUNA STATE

Telephone; 242222 PBX
Commissioner: 249721
Perm Sec.: 062-249722
Telegram: SECEDUCATE

Ref: NCE/STAT.3/Vol.II/.....

State Secretariat
Independence Way,
Private Mail Bag No. 2017
Kaduna Nigeria

Date: 23/7/15

The DIRECTOR
E.R.C.
KADUNA

PERMISSION TO CONDUCT RESEARCH

The bearer Mal/Mr./Mrs./~~Miss/Messrs~~: JOSEPH MAJIYEBO TIMAYI is a student from: ABU ZARIA

conducting a research on: Effects of Jigsaw IV Cooperative learning on Academic performance and interest of Secondary School Students in geometry in Kaduna State, Nigeria.

for the award of M.Ed (MATHEMATICS)

I am directed to convey the Ministry of Education's approval for the above research. Give him/her your maximum co-operation please.

Officer's Name YAKUBU UBALE ELISHA Signature

Designation DD/PRS Date 23/7/15

( )
For: Hon. Commissioner

Appendix 16

```
ONEWAY Pretest BY Score
  /MISSING ANALYSIS
  /POSTHOC=SCHEFFE ALPHA(0.05).
```

Oneway

```
[DataSet4] C:\Users\HP\Desktop\`Research work\Maths research\Data\Pretest GPT
. Scores.sav
```

ANOVA

Pretest

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	541.625	3	180.542	5.301	.002
Within Groups	5313.150	156	34.059		
Total	5854.775	159			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Pretest

Scheffe

(I) Score	(J) Score	Mean Difference (I-J)	Std. Error	Sig.	95% ... Lower Bound
GSS Dakachi	GSS T/Jukun	-2.525	1.305	.294	-6.21
	GSS K/Kuyanbana	-4.225*	1.305	.017	-7.91
	GSS Aminu	-4.700*	1.305	.006	-8.39
GSS T/Jukun	GSS Dakachi	2.525	1.305	.294	-1.16
	GSS K/Kuyanbana	-1.700	1.305	.638	-5.39
	GSS Aminu	-2.175	1.305	.430	-5.86
GSS K/Kuyanbana	GSS Dakachi	4.225*	1.305	.017	.54
	GSS T/Jukun	1.700	1.305	.638	-1.99
	GSS Aminu	-.475	1.305	.988	-4.16
GSS Aminu	GSS Dakachi	4.700*	1.305	.006	1.01
	GSS T/Jukun	2.175	1.305	.430	-1.51
	GSS K/Kuyanbana	.475	1.305	.988	-3.21

Multiple Comparisons

Dependent Variable: Pretest

Scheffe

(I) Score	(J) Score	95% ... Upper Bound
GSS Dakachi	GSS T/Jukun	1.16
	GSS K/Kuyanbana	-.54
	GSS Aminu	-1.01
GSS T/Jukun	GSS Dakachi	6.21
	GSS K/Kuyanbana	1.99
	GSS Aminu	1.51
GSS K/Kuyanbana	GSS Dakachi	7.91
	GSS T/Jukun	5.39
	GSS Aminu	3.21
GSS Aminu	GSS Dakachi	8.39
	GSS T/Jukun	5.86
	GSS K/Kuyanbana	4.16

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

Pretest

Scheffe[a]

Score	N	Subset for alpha = 0.05	
		1	2
GSS Dakachi	40	8.05	
GSS T/Jukun	40	10.58	10.58
GSS K/Kuyanbana	40		12.28
GSS Aminu	40		12.75
Sig.		.294	.430

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 40.000.

Appendix 17

```
GET
  FILE='C:\Users\HP\Desktop\`Research work\Maths research\Data\Post GPT Score
s.sav'.
DATASET NAME DataSet2 WINDOW=FRONT.
T-TEST GROUPS=Scores(1 2)
  /MISSING=ANALYSIS
  /VARIABLES=GPTest
  /CRITERIA=CI(.95).
```

T-Test

```
[DataSet2] C:\Users\HP\Desktop\`Research work\Maths research\Data\Post GPT Sc
ores.sav
```

Group Statistics

	Score	N	Mean	Std. Deviation	Std. Error Mean
GPT	Experimental	72	65.72	11.564	1.363
	Control	72	36.44	10.648	1.255

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
GPT	Equal variances assumed	.599	.440	15.804	142
	Equal variances not assumed			15.804	141.044

Independent Samples Test

		t-test for Equality of Means			
		Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence ... Lower
GPT	Equal variances assumed	.000	29.278	1.853	25.616
	Equal variances not assumed	.000	29.278	1.853	25.615

Independent Samples Test

		t-test for Equality of ...
		95% Confidence ...
		Upper
GPT	Equal variances assumed	32.940
	Equal variances not assumed	32.940

Appendix 18

```
T-TEST GROUPS=GPT(1 2)
  /MISSING=ANALYSIS
  /VARIABLES=Score
  /CRITERIA=CI(.95).
```

T-Test

```
[DataSet2] C:\Users\HP\Desktop\`Research work\Maths research\Data\Post GPT Sc
ores.sav
```

Group Statistics

	Male/Female	N	Mean	Std. Deviation	Std. Error Mean
Male/Female	Male	40	66.10	12.651	2.000
	Female	32	65.25	10.223	1.807

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Male/Female	Equal variances assumed	.753	.388	.308	70
	Equal variances not assumed			.315	69.988

Independent Samples Test

		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Male/Female	Equal variances assumed	.759	.850	2.760
	Equal variances not assumed	.753	.850	2.696

Independent Samples Test

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
Male/Female	Equal variances assumed	-4.655	6.355
	Equal variances not assumed	-4.527	6.227

Appendix 19

```
GET
  FILE='C:\Users\SOKOYAME\Documents\Data Kruskal wallis.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
NPAR TESTS
  /K-W=Interest BY Groups(1 4)
  /MISSING ANALYSIS.
```

NPar Tests

```
[DataSet1] C:\Users\SOKOYAME\Documents\Data Kruskal wallis.sav
```

Kruskal-Wallis Test

Ranks

	Groups	N	Mean Rank
Geometry Interest	Pre Experiment	72	96.54
	Pre Control	72	74.18
	Post Control	72	155.13
	Post Experiment	72	252.15
	Total	288	

Test Statistics[a,b]

	Geometry Interest
Chi-Square	196.995
df	3
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Groups

Appendix 20

```
NPAR TESTS
  /K-W=GInterest BY Gender(1 4)
  /MISSING ANALYSIS.
```

NPar Tests

```
[DataSet1] C:\Users\SOKOYAME\Documents\Data Kruskal wallis.sav
```

Kruskal-Wallis Test

Ranks

	Gender	N	Mean Rank
Geometry Interest	Male control	42	38.33
	Female control	30	34.78
	Male Experiment	42	108.45
	Female Experiment	30	107.72
	Total	144	

Test Statistics[a,b]

	Geometry Interest
Chi-Square	105.564
df	3
Asymp. Sig.	.000

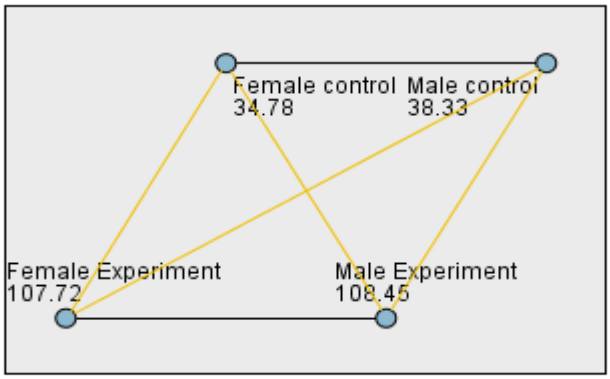
a. Kruskal Wallis Test

b. Grouping Variable: Gender

Appendix 21

Dunn-Bonferroni Post Hoc Test Test for Kruskal-Wallis

Pairwise Comparisons of Gender



Each node shows the sample average rank of Gender.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Female control-Male control	3.550	9.958	.356	.721	1.000
Female control-Female Experiment	-72.933	10.756	-6.781	.000	.000
Female control-Male Experiment	-73.669	9.958	-7.398	.000	.000
Male control-Female Experiment	-69.383	9.958	-6.967	.000	.000
Male control-Male Experiment	-70.119	9.091	-7.713	.000	.000
Female Experiment-Male Experiment	.736	9.958	.074	.941	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.