IMPACTS OF JIGSAW II CO-OPERATIVE LEARNING STRATEGY ON ACADEMIC PERFORMANCE AND RETENTION IN MENSURATION AMONG SENIOR SECONDARY SCHOOL STUDENTS IN KANO STATE, NIGERIA.

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Declaration

I, YAKUBU Lawan, registration number MED/EDUC/00854/2008-2009, declare that the work in this dissertation entitled "Impacts of Jigsaw II co-operative learning strategy on academic performance and retention in mensuration among senior secondary school students in Kano state, Nigeria" has been carried out by me in the department of Science Education. The information derived from the literature review has been duly acknowledged in the text and in the reference list provided.

_____ _____

Lawan YAKUBU Date

Certification

This Dissertation entitled “Impacts of Jigsaw II co-operative learning strategy on academic performance and retention in mensuration among senior secondary school students in Kano state, Nigeria” by Lawan YAKUBU meets the regulations governing the award of Master Degree in Mathematics Education of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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Dedication

This work is dedicated to my beloved uncle, Late Malam Abdullahi Aliyu (Sotal) who passed away in my first year of this programme, for his fatherly concern in the progress of each and every member of our family. May his gentle soul rest in perfect peace. Amin.

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Abstract

This study investigated the impacts of Jigsaw II cooperative learning strategy on students' academic performance and retention in mensuration concepts among senior secondary school students in Kano state, Nigeria. In this study, four (4) research questions were raised and answered. Also, four (4) hypotheses were formulated and tested at 0.05 level of significance. The study adopted the quasi-experimental non-randomized pre-test-post-test control group design. The target population of the study was all SSI students of public secondary schools in Kano state, totaling 69,736 from which four (4) intact classes from four schools were selected using simple random sampling technique. Two intact classes with 82 students were randomly assigned to experimental group and the other two with 77 students assigned to control group. Thus, the sample size was 159 SS1 students. The study made use of two (2) instruments, Geometry Achievement Test (GAT) and Geometry Retention Test (GRT). GAT was constructed by the researcher and contained 30 multiple choice items. GRT also contained 30 multiple choice items, constructed by swapping the items in GAT. Using split-half method, the reliability coefficient of GAT was 0.74. GAT was used as pretest and as posttest while GRT served as Post-posttest (Retention test). Both experimental and control groups took GAT as a pre-test before the experiment started. Experimental group was then taught mensuration concepts for six (6) weeks using jigsaw II cooperative learning strategy while the control group was taught the same topics for the same period using conventional lecture method, after which GAT was taken by both groups. GRT was administered on both groups two weeks after taking GAT. Data collected was analyzed using independent t-test.. Findings showed that the mean performance score of the experimental group was significantly higher than that of the control group. In terms of gender, findings revealed that there was no significant difference between the mean performance score of males and females when taught by using jigsaw II co-operative learning strategy. It is recommended that mathematics teachers should be trained by State Ministry of Education on how to implement jigsaw II cooperative learning in their classrooms by organizing seminars and workshops in order to improve students' performance and retention ability in mathematics.

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ABBREVIATIONS

CCI - Computer Cooperative Instruction

CIRC - Computer Integrated Reading and Composition

GAT - Geometry Achievement Test

GRT - Geometry Retention Test

ICI - Individualized Computer Instruction

KERD - Kano Educational Resource Department

NERDC - Nigeria Educational Research and Development Council

NMC - National Mathematical Centre

PISA - Programme for International Students' Assessment

SMET - Science, Mathematics, Engineering and Technology

STAD - Students Teams Achievement Division

TAI - Team Accelerated Instruction

TGT - Team Games Tournament

TIMSS – Trends in International Mathematics and Science Study

OPERATIONAL DEFINITIONS OF TERMS

Jigsaw II Co-operative Learning Strategy: An instructional strategy in which students work in small groups to discuss, share ideas and elaborate on a learning material among themselves in order to accomplish a learning task and attain a group reward.

Conventional Lecture Method: A teaching method where the teacher dominates major part of classroom activities. In this method, every student works alone during explanation, discussion and application of mathematics concepts throughout the lesson delivery. Students are allowed to ask and answer few questions.

Academic Performance: Student meets a set standard to a level which demonstrates adequate understanding of the mathematics concepts taught.

Retention: A student has an ability to recall or recognize mathematics concept learnt before.

Mensuration: An area in geometry which deals with the measurement of length, area and volume of an object.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

Mathematics is primarily concerned with ideas, processes and reasoning leading to the solutions of problems. It is widely recognized as a necessary tool for achieving the development goals of any society. This is because the development of any nation depends on her scientific and technological advancements. However, there can be no science and technology without mathematics (Musa, 2006). The application of mathematics cuts across all areas of science, technology, commerce, agriculture, health, etc. It is in recognition of this importance that mathematics is made one of the core subjects that students must study at both basic and post-basic levels of education. Mathematics education, therefore, is indispensable to both individual and national development.

Mensuration is an area in geometry which deals with measurement of an object for the purpose of comparing its size with some standard units (Odili,2006). Further, Musa and Bolaji (2015) defined mensuration as a science of numerical representation of geometrical magnitudes. These measurements can be linear mensuration such as lengths, area mensuration or volume mensuration .Mensuration is very important because most of the objects human being deals with, have some shapes that possess either area or volume. Odili (2006) emphasized that we live in 3-Dimensional space that has volume. Thus, mensuration can be regarded as the backbone of the study of geometry.

Geometry is the branch of mathematics that studies space and spatial relationship (Hassan, 2010). It is a way of reasoning that can be used to understand and analyze imagined

spatial and physical environment. Choi (2013) observed that geometry offers ways to interpret and reflect on the physical environment which enables students to link geometry to their daily lives.

The study of geometry contributes immensely in assisting students to develop skills of critical and logical thinking, problem solving and deductive reasoning. Therefore, geometry is a source of mathematical thinking. It kindles man's interest in observing shapes around him and making conjectures about their relationships which further stimulates curiosity and encourages exploration. Geometry is an interesting area of mathematics full of surprising theorems and wonderful problems. Hassan (2010) posited that the ability to apply geometric concepts and theorems is a life skill needed in many occupations. In fact, learning of geometry greatly enhances learning of other areas in mathematics. This is because geometrical illustrations are usually used to visualize other mathematical concepts clearly. Hence, it will not be an exaggeration to say that geometry occupies the highest practical aspect of mathematics and it is the mother of all other branches of mathematics. Therefore, it can be argued that if mathematics is to be made real and interesting, then, full attention must be paid to the teaching and learning of geometry.

However, despite the importance of mathematics to the individual and the society, literature review constantly reveals persistent low students' performance at all levels. For instance, Eniayeju and Azuka (2010) lamented that statistics from West African Examinations Council

(WAEC) indicated that from 2000 – 2009, less than 40% of Nigerian students obtained credit passes in mathematics in each of the 10 years in SSCE. Uyuota (2006) rightly cautioned that poor performance in mathematics at secondary level has spill- over effects on tertiary level

mathematics. Further, Olusunde and Olaleye (2010) described poor performance as a loss in a country's financial investment.

Poor performance in mathematics is also evident among Kano state senior secondary school students. Data collected from Kano Educational Resource Department (KERD) revealed that unprecedented number of candidates persistently performed poorly in SSCE in mathematics. This is presented in Table 1.1:

Table 1.1: Summary of students' performance in mathematics SSCE in Kano state from 2005-2013

Year	No. of registered Students	No. of students with credits A1 – C6	No. with passes D7-E8	No. with Fail F9
2005	21251	816 (3.8%)	8268 (38.9%)	12167(57.3%)
2006	26916	5725(21.2%)	13196(56.5%)	5995(22.3%)
2007	28414	5339(18.8%)	13996(49.3%)	9070(31.9%)
2008	31481	4142 (13.1%)	10464 (33.3%)	16875(53.6%)
2009	47075	9388 (19.9%)	35649 (75.7%)	2038 (4.4%)
2010	43329	6100 (2.6%)	6932 (15.9%)	35292(81.5%)
2011	29492	2302 (7.8%)	10478 (35.5%)	16712 (56.7%)

2012	37935	7053 (18.6%)	22421 (59.1%)	8461 (22.3%)
2013	32665	11000 (33.7%)	12617 (38.6%)	9048 (27.7%)

Source: Kano Educational Resource Department (2014)

The implication of the above information is that from 2005 – 2013, the highest percentage of Kano state students that qualified for admission into science and technical courses in Nigerian universities is approximately 30% with some years having less than 5%. This is because of lack of credit pass in mathematics. This is quite alarming.

Specifically, researchers reported poor academic performance in geometry due to students' and even teachers' perceived difficulty in teaching and learning the area (WAEC, 2005; Abbas, 2008; Hassan, 2010; Idehen, 2012; Choi, 2013). Hassan (2010) lamented that students find it difficult to accurately measure, construct, draw and even re-arrange objects which are basic processes involved in the study of geometry. As for teachers, Idehen (2012) showed that teachers had misconception about the differences between a cube and a cuboid and seemed not to understand the best description of a cube. It is this misconception that teachers pass to students in a geometry class that leads to wrong solution of geometry problems. The implication of this situation is that geometry makes the least impression on students and their teachers. As such, they avoid anything geometry and students fail even if they attempt solving geometrical problems.

Another major obstacle that hinders students' performance and progress in mathematics is their inability to retain the learnt concepts. Retention, according to Bichi (2000), is the ability to keep and consequently remember learnt or experienced material at a later time. Retention

facilitates transfer of learning for problem solving. When students cannot remember what they learnt before, they become confused. Such confusion can be the beginning of mathematics-phobia and avoidance of the subject (Uyuota, 2006). Adeyemi (2003) stressed the importance of retention of learnt concepts by observing that the ways children learn and perceive are reflected in retention scores and that which is imperfectly registered cannot be perfectly retained.

Various factors responsible for students' poor performance and retention in geometry and mathematics generally have been identified by researchers in mathematics education. These include lack of enough and qualified teachers, inadequate instructional materials, large class size and poor students' background. However, other findings have revealed that the most important factor is the use of poor teaching strategy in teaching mathematics. Such findings have agreed that low performance and poor retention ability among students are largely due to inappropriate instructional strategy (Adeyemi, 2003; Usman,2004; Hassan, 2010; Obioma, 2011; James & Taiwo, 2011).

Empirical evidences (Bolaji, 1999; Azuka, 2009; Adewumi, 2012) have indicated that traditional lecture method still remains popular among secondary school mathematics teachers. In the traditional method, the teacher dominates the class with little opportunity for students to participate. Despite this shortcoming, the method is important as it consumes less lesson time and can be used to teach large class. FME (2007) argued that the method can be used to supplement other innovative methods by making initial presentation of materials and giving clear instructions to students, either in group or individually. Teaching mensuration aspect of

geometry is not an exception in this regard. This shows that much is needed in the area of teaching and learning of mensuration aspect of geometry in order to actualize the desired goals. The Royal Society (2001), in Nichols (2002), opined that one of the current major concerns is about how to improve instructional strategies in order to assist students successfully progress from practical geometry to deductive geometry. One of these improved and innovative strategies is the co-operative learning. There are various versions of co-operative learning; one of them is known as jigsaw II co-operative learning strategy.

Jigsaw II co-operative learning strategy is an instructional strategy in which small groups, each with students of different ability levels, use variety of learning activities to improve their understanding of a lesson. The Jigsaw II cooperative learning strategy is an efficient way for students to learn classroom material. The process encourages students to listen and be engaged in a group setting. Just like a jigsaw puzzle, each member of the group plays an essential role in their group. What makes this strategy so effective is that group members work together as a team to achieve a common goal. Students are not able to succeed unless everyone works together (Chan, 2004). In this strategy, each student is a member of two groups (jigsaw or home group and an expert group). In the jigsaw or home group, students are assigned separate portions of the material to be learnt. Each member in the home group is asked to focus on reading one portion of the material. Upon finishing the reading, students who read the same portion of the material come together to form an expert group to discuss their assigned portion. After the discussion, group members go back to their home group to teach what they have learnt in their expert group

to other members. After mastering all the sub-topics taught by each expert, individual group members take a short quiz. Individual score is compared with the base score to calculate the individual improvement score, based on which a group's average improvement score is worked out. The group having the highest average group improvement score is given group recognition by getting a group reward. Alternatively, a group which has its average group improvement score reaching a pre-determined level can receive a group reward. Thus, each member learns and helps his mates to learn since the success of a group member is the success of all members. Therefore, jigsaw II co-operative learning strategy is a strategy which makes learning and working together a way of life among students.

Moreover, scholars have observed and reported the problem of gender disparity in the students' performance in geometry and participation in mathematics (Amali, Ojogbane and Akume, 2004; Kurumeh, 2006; Abbas, 2008; Ebisine,2010; Haruna, 2012). Researchers in mathematics education have attributed gender performance differences in mathematics to the instructional strategies employed by teachers (Okpala & Onocha, 1998; Amali, Ojogbane & Akume, 2004; Kurumeh, 2006).

Therefore, it can be seen that other strategies need to be evolved and tried in order to realize the much desired improved academic performance, retention of learning and gender parity in mathematics. In view of this, the present study investigated the impacts of one of the innovative strategies, jigsaw II co-operative learning strategy, for possible improvement in academic performance, retention ability and gender performance in mensuration aspect of geometry.

1.2 Statement of the Problem

For any meaningful learning to occur, classroom experiences presented by teachers should be made meaningful to the students. Therefore, teachers often struggle to make choice pertaining to method of teaching to use in their classrooms which will rekindle students' interest and stimulate their thinking. The task of selecting a method that will serve these purposes is not an easy one for the teachers. This is because there is no single method that works well for everyone and for every situation. It is the duty of every teacher to identify suitable instructional strategy for his class, bearing in mind the topic, the students' capability and teacher's familiarity with the strategy for enhanced achievement in mathematics.

However, the researcher observed that students' performance in mathematics qualifying examination (Mock SSCE) conducted by KERD and even SSCE conducted by WAEC and NECO has been consistently very poor in Kano State (refer to Table 1.1 for evidence). As one of the examiners in qualifying examination and SSCE, the researcher observed that students rarely answer or totally avoid attempting questions on mensuration aspect of geometry. Where they even make attempt, they fail or score very low.

Further, in the course of interaction with mathematics teachers during various workshops, the researcher observed that teachers' attitude towards geometry and their understanding of mensuration aspect of geometry was not encouraging. Such teachers also blamed students' inability to recall geometrical concepts, formulae and theorems as one of the reasons for the difficulty they encounter in teaching and learning geometry.

Based on the identified students' and teachers' difficulties in mensuration aspect of geometry, the researcher is of the view that most teachers failed to deliver the geometry content they want to teach because of the use of inappropriate and irrelevant instructional strategy. This, among other factors, immensely contributes to students' poor performance and retention in geometry and mathematics generally. This calls for the urgent need to explore and apply other effective instructional strategies that have been found to improve performance and retention of learning in some other environments.

Therefore, the problem of this study is to investigate what will be the impacts of Jigsaw II co-operative learning strategy in order to determine its effects on students' performance, retention and gender performance in mensuration aspect of geometry at senior secondary school level in Kano State.

1.3 Objectives of the Study

The objectives of the study are to:

1. investigate the impact of jigsaw II co-operative learning strategy on performance in mensuration aspect of geometry among senior secondary school (SSS) students in Kano state.
2. explore the impact of jigsaw II co-operative learning strategy on retention ability among students in mensuration in Kano state.
3. determine the effect of jigsaw II co-operative learning strategy on gender and performance in mensuration aspect of geometry among SSS students in Kano state.

4. investigate the impact of jigsaw II co-operative learning strategy on retention ability in mensuration concepts by gender at SSS level in Kano state.

1.4 Research Questions

In order to achieve the objectives of the study, the following research questions were formulated:

1. What is the difference between the mean performance scores of students taught mensuration concepts using jigsaw II co-operative learning strategy and those taught using the conventional lecture method?
2. What is the difference between the mean retention scores of students taught mensuration using jigsaw II co-operative learning strategy and those taught using conventional lecture method?
3. What is the difference between the mean performance scores of males and females when taught mensuration concepts using jigsaw II co-operative learning strategy?
4. What is the difference between the mean retention scores of males and females students taught mensuration by jigsaw II co-operative learning strategy?

1.5 Null Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

1. $HO_{1:}$ There is no significant difference between the mean performance scores of students taught mensuration concepts using jigsaw II co-operative learning strategy and those taught using conventional lecture method.

2. HO_2: There is no significant difference between the mean retention scores of students taught mensuration using jigsaw II co-operative learning and those exposed to conventional lecture method.
3. HO_3: There is no significant difference in the mean performance scores of male and female students taught mensuration by jigsaw II co-operative learning strategy.
4. HO_4 : There is no significant difference between the mean retention scores of male and female students in mensuration aspect of geometry when exposed to jigsaw II co-operative learning strategy.

1.6 Significance of the Study

The study will hopefully benefit the following:

Mathematics Students: The study will hopefully benefit students immensely by reducing the general mathematics – phobia worrying them, especially at post-basic level of education due to the use of ineffective instructional strategies by mathematics teachers. This is because as students learn from their peers and also teach their peers, the perceived tension in learning mathematics is relaxed. Thus, the study will benefit students in Kano State.

Mathematics teachers: It is also hoped that the findings of the study will also reduce the distaste students and their teachers have towards teaching and learning geometry by changing their view

of geometry as a difficult area in mathematics. Mathematics teachers will come to realize that with the application of suitable methods of teaching, like jigsaw II co-operative learning strategy, mensuration, in particular, and geometry in general, can be easily taught and learnt by students.

Textbook publishers: Also, the study will hopefully benefit textbook developers by advocating appropriate instructional strategies in teaching geometry such as jigsaw II co-operative learning in their subsequent publications for improved teaching and learning of mathematics at SSS level. Educational administrators: It is hoped that the study will provide materials that could be used to enrich training and re-training packages for both pre- service and in-service mathematics teachers. This will help educational planners and administrators as well as professional bodies in mathematics when it comes to mathematics teacher professional development.

Professional bodies in mathematics: The findings of this research could serve as a reference material for teachers and professional bodies in mathematics like MAN and STAN to recognize possible gender differences among students in terms of academic performance and retention in mathematics and plan how to popularize the subject among all the students to minimize gender differences by application and support towards implementation of jigsaw II co-operative learning strategy. Therefore, it is hoped that the findings of the study will hopefully contribute towards the resolution of the debate on gender and performance in mathematics, particularly the geometry aspect. In this regard, it is anticipated that the results of this study will provide further empirical evidence as to methods of teaching that could be adopted to reduce differences in gender performance in geometry.

Parents: The study could help provide strong empirical basis for improvement and modification of the methods of teaching mathematics which could lead to improved academic performance

among students. Such improvements and modifications will also make parents to be happy to see their children passing mathematics for their future educational progress.

Fellow researchers: It is hoped that the findings of the study will stimulate and promote further researches. Fellow researchers in mathematics education will find the results worthy of discussion and dissemination to stimulate and promote further researches. In addition to that, fellow researchers will also benefit from the study by providing them with recent literature materials that will guide them in carrying out further researches in mathematics education.

1.7 Scope of the Study

The scope of the study was limited to class one of public senior secondary schools in Kano state because it is expected that at the end of year 3 of JSS, they have covered the pre-requisite topics for learning mensuration at senior secondary level which is needed for independent work in a co-operative learning set-up. Also, SS 1 students were selected because they are more stable than SS11 and SS 111 as SS11 are busy preparing for their Mock SSCE (Qualifying examination) while SS III are also busy preparing for final SSCE.

The study was limited to four (4) selected secondary schools in two zonal education offices in Kano state, to investigate the effectiveness of jigsaw II co-operative learning strategy over the conventional lecture method. Thus, the study did not go into other causes of poor performance beyond the issue of teaching methods.

Further, the study covered only single sex schools since Kano state does not operate co-education system in public senior secondary schools.

Also, the scope of the study covered topics in mensuration aspect of geometry. Specifically, topics considered are surface areas and volumes of cubes, cuboids and cylinder. This is because

literature search showed that students have difficulties in the area as pointed out by (NMC, 2006; WAEC, 2011; Idehen,2012;Sam-Kayode & Salman, 2015).

The study was limited to the use of two instruments, Geometry Achievement Test (GAT) and Geometry Retention Test (GRT). Each of GAT and GRT contained thirty (30) multiple choice items so as to allow for a wide coverage of assessment on mensuration concepts covered in the study.

1.8 Basic Assumptions

1. Each group of students used in the study possesses similar learning characteristics needed for effective group work in jigsaw II co-operative learning set-up.
2. All the subjects used in the study have opportunity to learn the materials covered in the topics and the test administered. They also have similar pre-requisite knowledge for the understanding of the content taught in the study by covering up to the third term syllabus of Junior Secondary School three
3. The samples for the study were familiar with the use of co-operative learning strategy.
4. The schools that were chosen for the study have similar teaching and learning facilities and resources needed for implementation of jigsaw II co-operative learning.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

The main objective of this study was to investigate the impact of jigsaw II co-operative learning strategy on senior secondary school students' academic performance and retention of geometric concepts. This chapter, therefore, reviewed literature related to the present study. The review focused on the following sub-topics: Theoretical Framework, Performance Trend in Secondary School Mathematics, Co-operative Learning Instructional Strategies, Jigsaw II Co-operative Learning Strategy, Instructional Delivery Using Jigsaw II Co-operative Learning Strategy, Traditional Lecture Method of Teaching Mathematics, Instructional Delivery Using Traditional Lecture Method, Teaching and Learning Geometry in Secondary Schools, Gender and Performance in Mathematics, Jigsaw II Co-operative Learning and Retention Ability in Geometry, Overview of Related Studies and Implications of Reviewed Literature for the Present Study.

2.2 Theoretical Framework

Prior to World War II, social theorists like Allport and Watson began establishing a co-operative learning theory after finding out that group work was more effective and efficient in quantity, quality and overall productivity when compared with working alone (Gilles and Adarian, 2003). In the 1930's and 40's , psychologists such as John Dewey and Kurt Lewin also influenced co-operative learning theory practiced today. They believed that it was important for students to develop knowledge and social skills that could be used outside classroom and in the

democratic society. Their theory portrayed students as active recipients of knowledge by discussing information and answers in groups, engaging in learning process together rather than

being passive receivers of information, leading to construction of their own knowledge (Sharan,2010). Therefore, co-operative learning method adopts the concept of constructing knowledge of constructivism theory.

Constructivism theory claims that knowledge should not be transferred from one individual to another in an educational environment rather it should be actively constructed. The learner, to a constructivist, is an entity with previous experiences that must be considered as a 'knowing being'. As learners encounter new situations, they look for similarities and differences against their own cognitive realm and try to come up with solutions. In constructivist terms, learning depends on the way each learner looks at a particular situation and draws his own conclusion. . Students, therefore, determine their own knowledge based on their own way of processing information and according to their own way of beliefs and attitudes.

Psychologists such as Piaget and Vygotsky emphasized the importance of peer assistance in a constructivist approach. This supports the assertion of Driver and Bell (1986) that learners accomplish understanding through the social interactions that occur in the classroom. Johnson and Driver (1990) maintained that cognitive construction is facilitated through some activities which are based on peer interaction necessary in co-operative learning. These activities are:

- Students present and explain their ideas to group members
- Students think and talk about their experiences
- Suggest and try new ideas

- Reflect on changes in their ideas
- Negotiate and help other students to clarify their ideas
- A new idea or knowledge is thus constructed

According to Slavin (1987), in Abu and Flowers (1997), there are two (2) major constructivism theoretical perspectives related to co-operative learning. These are motivational and cognitive theories. The motivational theory emphasized the students' incentives to do academic work. Motivational theory focused on reward and goal structures. From a motivational perspective, co-operative goal structure creates a situation in which the only way group members can attain their personal goal (reward) is if the group is successful. Therefore, in order to attain personal goal (reward) students must encourage group members to help one another with a group task (Slavin, 1990).

There are two cognitive theories that are related to co-operative learning: The developmental theory and the elaboration theory. The developmental theory assumes that interaction among students around appropriate learning task increases their mastery of concepts learnt. According to this theory, Damon (1984) in Abu and Flowers (1997) pointed out that when students interact with their peers, they explain and discuss each other's perspective which results in greater understanding of learnt material as well as development of higher levels of academic performance (Slavin, 1990).

The elaboration theory, on the other hand, suggests that one of the most effective means of learning is to explain the material to someone else. Co-operative learning enhances elaborative thinking, giving and receiving explanation which have the potential to increase understanding,

quality of reasoning and long-term retention (Johnson, Johnson & Holubec, 1986). In this sense, Vygotsky (1978) showed that learners who experience the processes involved in their own thinking in a group setting will come to experience self-actualization in their own thinking which enhances their learning. Therefore, from both motivational and cognitive theoretical bases, it is

expected that the use of jigsaw II co-operative learning strategy should lead to improved academic performance and retention of learnt concepts..

The present study adopted the motivational and cognitive theories of constructivism of Vygotsky (1978) to explore the effectiveness of jigsaw II co-operative learning strategy in teaching mensuration aspect of geometry at senior secondary school level in Kano state to provide empirical evidence on the relevance of the theory in the study area and in the present times.

2.3 Performance Trend in Secondary School Mathematics

Students' performance in mathematics has been an issue of concern to all stakeholders in education. Statistics indicated that there is persistent poor performance in mathematics at secondary school level. For instance, Odili (2006) reported that from 1991-2000, the highest percentage pass at credit level in SSCE was 32.8% in Nigeria. The trend remained the same up to 2009 as Eniayeju and Azuka (2010) lamented that published statistics from West African Examinations Council WAEC (2011) revealed that for the past ten years, 1999-2009, less than 40% of Nigerian students obtained credit passes in mathematics in each of the years in SSCE.

The performance crisis is not only limited to senior secondary schools. Evidence of discouraging performance is apparent at all levels of our educational system. Rossier, in Uyuota (2006), compared Nigerian primary school pupils with pupils from other countries in science and mathematics. Results showed that Nigerian pupils came last with Japanese pupils coming first. This poor performance at the foundation level (primary), cautioned Uyuota (2006), has spill-over effects on junior secondary and even tertiary education. This effect is also evident in Rossier's report which further stated that Nigeria came second to the last in secondary school science

relative to students from other countries in the then 2nd International Science Study. The effect of such poor performance is adverse. Olusunde and Olaleye (2010) described poor performance as a colossal loss in terms of financial investment of the nation.

Various factors responsible for this ugly trend have been identified by researchers in mathematics education. Obioma (2011) identified poor method of teaching as one of the factors largely responsible for students' poor performance in mathematics. This supported Eniayeju and Azuka (2010) who revealed that mathematics teachers rated method of teaching as average/above average among the factors affecting effective mathematics teaching and learning. Other factors rated as above average are teachers' knowledge of subject matter and possession of professional qualification. Salary and condition of service were rated below average. Further, Usman (2004) classified poor method of teaching as one of the micro problems leading to poor performance in mathematics. Micro problems are those problems considered internal to mathematics education. Other micro problems are class size and instructional materials (Usman, 2004). The urge to find solution to poor performance in mathematics made James and Taiwo (2011) to seek the view of students in Sokoto state about the possible causes of their dismal

performance in the subject. Results showed that out of the 280 students surveyed, 162 representing 58.3% agreed that poor method of teaching remains a factor responsible for their learning difficulty in mathematics. Other researchers who viewed inappropriate method of teaching as a strong factor leading to poor performance are Hassan (2010) and Okurumeh (2003).

Another strong factor leading to poor performance is students' attitude towards mathematics which has been negative. Yara (2009) indicated that there is a direct link between students' attitude and their learning outcomes in mathematics. However, positive students' attitude towards mathematics can be enhanced when suitable method of teaching is employed to teach the subject. This view was empirically established by Bolaji (2005), as cited by Yara (2009), that the teacher's method of teaching and his personality greatly accounted for the students' positive attitude towards mathematics.

It can be rightly argued that method of teaching mathematics adopted by the teacher has influence on students' performance. Therefore, if mathematics concepts must be learnt, retained and applied to solve problems, then, careful consideration must be given to methods by which subject matter, learner and the teacher will interact. Hence, the search for appropriate method of teaching various mathematical concepts is still on-going among researchers in mathematics education.

This study explored the impacts of jigsaw II co-operative learning instructional strategy on performance and retention ability of senior secondary students in mensuration when compared with the traditional lecture method of teaching.

2.4 Co-operative Learning Instructional Strategies

Various scholars have defined co-operative learning in various ways but all point to the fact that working together in order to accomplish learning task is the central idea behind any co-operative learning. In this sense, Ozekereha (2010) defined co-operative learning as a teaching strategy in which small groups, each with students of different levels of abilities, use a variety of learning activities to improve their understanding of a topic. In this strategy, each member of the group learns as well as helps his mates to learn.

Educators have identified various co-operative learning strategies. Some of the strategies utilize students pairing while others use small groups of 4, 5 or 6 students. Siltala (2010) examined the following strategies which he said can be used in any content area:

1. Think – pair – share: This was originally developed by Lyman (1981). In this technique, students are allowed to contemplate a posed question or problem silently. The student may write his thoughts or may simply just brainstorm in his mind. After that, the student pairs up with a peer and discusses his/her ideas with and listens to his partner's ideas. Following pair dialogue, the teacher solicits responses from the whole group.
2. Jigsaw: In this technique, students are members of two groups, i.e home group and expert group. In the heterogeneous home group, students are each assigned a different topic. After that students leave the home group and group with the other students with their assigned topic. In the new group (expert group), students learn the material together before returning to their home group. Once back in their home group, each student is responsible for teaching his assigned topic.

3. Jigsaw II: This is Slavin's (1980) version of jigsaw. Here, 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 assigned portion and teach the other members of the home group.
4. Reverse jigsaw: This was developed by Timothy Hedeen in 2003. The difference between jigsaw and reverse jigsaw is that students in the expert group teach the whole class rather than returning to their home groups to teach the content.
5. Students-Teams-Achievement-Divisions: In this technique, students are placed in small groups. The class, in its entirety, is presented with a lesson and students are subsequently tested. Individuals are graded on the team's performance. Although the tests are taken individually, students are encouraged to work together to improve the overall group performance.

Moreover, Colorado (2007) identified other techniques which he claimed to be more effective especially in teams of four and for language learners. These are: Round Robin, round-table, write-around, team jigsaw and tea party. Others identified by Chan (2004) are Team Games Tournament (TGT), Team Accelerated Instruction (TAI) and Co-operative Integrated Reading and Composition (CIRC). Chan (2004) posited that TAI is specifically designed for mathematics in grades 3-6 while CIRC is for reading and writing instruction in grades 2-8. According to Chan (2004), jigsaw II co-operative learning can be used across many subject areas (including mathematics) and across various grades.

In the context of this study, jigsaw II co-operative learning was used as a co-operative learning strategy to teach the experimental group. This is because the strategy has not been tried in the study area, to the best knowledge of the researcher. The strategy also permits students to examine all the various portions of a topic in a co-operative style to generate ideas. This study intends to use the strategy so as to increase the generalizability of its impacts in various settings.

2.5 Jigsaw II Co-operative Learning Strategy

Slavin (1990) saw jigsaw II as a teaching strategy that involves students with varied learning abilities undergoing group work in small teams in order to attain the group goal and group reward. Team work is done in two stages. Firstly, at expert group, where they learn a portion of a topic until they master the material. Secondly, at jigsaw group where they teach the material they learnt at expert group to their members.

Mattingly and Vansickle (1991) viewed jigsaw II as instructional use of small groups to learn materials and teach same to another group which is combined with reward to enhance co-operation towards attainment of a common goal.

Gambari, Olumorin and Yusuf (2013) submitted that jigsaw II requires students to work in groups of 4,5 or 6 students. Each student in a group is given information to which no one else in the group has access. Thus,making each student an expert on his or her section of the topic. Members of different teams who have studied the same material meet together to share information and solve the task. Their expert knowledge is shared with other members in the original home group. The group that excels in terms of improved performance is awarded group

reward. Therefore, jigsaw II emphasizes the use of group work and reward for co-operation to achieve group goal.

Jigsaw II was developed by Slavin (1980), having adapted the jigsaw co-operative learning strategy developed by Elliot (1971). In the design of jigsaw II, Slavin constructed in the strategy four (4) elements which characterize it and contribute to its success. According to Chan (2004), these characteristics are:

1. Mixed ability grouping
2. Individual accountability
3. Group reward
4. Equal opportunity to success

- Mixed ability grouping: Students are assigned to heterogeneous groups in terms of ability and possibly gender, so that each group is a cross-sectional representation of the whole class. The groups should be relatively small and as heterogeneous as circumstance permits. Chan (2004) reported that researches have shown that low ability students improve in heterogeneous groups due to the elaborated explanations they receive from high ability peers on the learning materials. As for the high ability students, Webb

(1992), cited by Chan (2004), argued that high ability students learn more in heterogeneous groups because when giving elaborated explanations to low ability students, they re-organize and clarify information in different ways which enhance their performance. However, Chan (2004) remarked that a teacher using jigsaw II can sometimes revise the group's composition slightly to smoothen implementation.

- Individual accountability: Individual accountability means that the success of a group depends on the successful individual learning of all the group members. Apart from responsibility for one's own learning, each member has to be responsible for facilitating the learning of other members of the group. Individual accountability exists when the performance of each individual member is assessed, the results are given back to the individual member and the group to compare against a standard of performance. This will allow a group to hold a member responsible for contributing his or her fair share to the success of the group.
- Group reward: Individual accountability can be fostered by effective use of group reward based on individual performance. Chan (2004) described group reward as a form of extrinsic reward which motivates group members to learn hard for themselves as well as to help each other to learn well. In short, group reward is an extrinsic reward given to a group in recognition of their co-operative effort. The type of reward to be given can be varied each time. It was also discovered that after several times of giving reward, students became intrinsically motivated and no longer require group reward which serves as extrinsic motivation.
- Equal opportunity to success: Jigsaw II uses improvement scores instead of actual individual test scores to compute the group score. If individual test scores are used to compute group score, low ability students will be perceived as a burden to the group. This is because it is difficult, if not impossible, for the low ability level students to score as high as the high ability ones. With improvement scores, members of different ability

levels are given an equal opportunity to earn points towards the group score as long as they make improvement over their past performance, irrespective of their actual score. In this sense, Chan (2004) posited that the only rival is oneself but other group members are friends.

It is worthy to note that the major difference between jigsaw developed by Elliot and jigsaw II by Slavin is in the area of group reward which is absent in the original jigsaw of Elliot. Secondly, jigsaw II uses improvement scores not individual test scores as used in Elliot's jigsaw. Improvement scores strengthen group co-operation more than individual scores as observed by Chan (2004).

2.5.1 Instructional Delivery Using Jigsaw II Co-operative Learning Strategy

The implementation of jigsaw II co-operative learning strategy comprises of five (5) steps. Chan (2004) identified these steps as follows:

1. Reading
2. Expert group discussion
3. Home group reporting
4. Testing
5. Group recognition

These steps are discussed below:

- Reading: The material to be learnt is divided into portions. Each student in a group is asked to focus on reading one portion of the material. Each student is given an identical reading material relevant to the topic as well as an expert sheet. For groups of four students, the expert sheet consists of four questions, each of which focuses on one portion of the material to be learnt. For instance, surface area of a cube can be divided into portions like:
    1. Finding the surface area given the length
    2. Finding the length given the area
    3. Comparing surface area of two cubes
    4. Application of surface area of a cube to practical problems

  Every member of the group is responsible for finding answers to one of the questions in the expert sheet from reading the relevant part of the material. The questions on the expert sheet can be randomly assigned to the group members. Chan (2004) recommended that reading of the material can be done as home work to save the lesson time.

- Expert group discussion: students working on the same question in the expert sheet form an expert group. For groups of four students, four expert groups are thus formed. In order to facilitate the discussion, the teacher can be going round to ask guiding questions for each expert group. Each member is encouraged to take notes of what has been discussed in the expert group to help in teaching home group members. Whenever problem arises, students should be allowed to handle it by themselves before seeking teacher's intervention.

- Home group reporting: students in the expert group are asked to go back to their original home groups to teach the other members what they have discussed in their respective expert groups. They are reminded to assist each other to master the material learnt as

individual success counts towards group's success. After each member has shared his or her expert knowledge with each other, it is advisable and useful for the teacher to conduct a short, whole class discussion to clear doubts, if any, as well as provoke further discussion on the topic.

- Testing: After mastering the learnt material, members of each group take an individual short test. Chan (2004) advised that the test items can be in form of multiple choice. Immediately after the test, members exchange their test papers to mark the answers. The individual test scores are then computed as improvement scores by comparing with the base scores that represent student's past performance.
- Group recognition: If the average group improvement score (calculated by adding the total improvement score of the group members and dividing by the number of group members) reaches a pre-determined level, each member of the group will be awarded a group reward. Alternatively, the group with the highest average group improvement score is given a group recognition by getting a group reward. Each member of the group gets the same reward, irrespective of his or her individual performance in the test. The purpose of using improvement scores is to strengthen group co-operation among members. Chan (2004), while implementing jigsaw II to teach curriculum as a topic to in-service teachers in Hong-Kong, used a certificate which he designed as group reward. But Chan (2004) recommended that group reward can take other forms that the group members treasure. Mattingly and Vansickle (1991) suggested that for maximum results using jigsaw II, groups must work towards a group goal and reward which can be

achieved only by working together. Also, students must be publicly accountable to their peers for their individual contributions to the success of the group.

This study examined jigsaw II co-operative learning strategy in Kano state senior secondary schools in order to compare its effectiveness with the conventional lecture method in teaching mensuration. This was done with the hope of establishing empirical evidence of possible improved performance and retention ability in the study area when jigsaw II is employed.

2.5.2 Groups Formation for Co-operative Learning

One of the characteristics of co-operative learning is that groups need to be heterogeneous. Felder and Brent (2001) recommended that to teach course content effectively, making ability heterogeneous should be the primary criterion in forming teams. Further, Felder and Brent (2001) recommended two options for forming heterogeneous group:

- To find out about students' abilities at the beginning of co-operative learning lessons, have students fill out a questionnaire in which they give their grades in pre-requisite courses. Based on this grade, form a 3 – 4 person team that is heterogeneous in ability as measured by the grades in the pre-requisite courses. Announce the groups and make any necessary adjustment. If the lesson requires meeting outside, then, the

  questionnaire should contain an hour-by-hour matrix of the week including weekends. Students can cross out the times they cannot meet outside the class because of conflicting schedules.

- To form a stable and permanent group, one can form a practice group by random assignment and announce that a permanent group will be formed two weeks later. Sometimes during those two weeks, give a quiz. At the end of the two weeks, let the students fill out the questionnaire. Using the quiz grades along with the pre-requisite grades as measures of ability levels, form the permanent groups.

However, in an attempt to group NCE students into various ability levels (high, medium and low), Dambatta (2010) used the students' Grade Point Average (GPA). One of the objectives of the study was to find out the effects of concept mapping on the performance of various ability levels in trigonometry. Similarly, Foyewa (2014) attempted to classify students' performance to ascertain the general achievement level of NCE 3 students in Oyo State College of Education in a general English course. He classified students as follows:

A – B = 100 – 60 as High Achievers, C – D = 59 – 45 as Medium Achievers and

E – F = 44 – 0 as Low Achievers

Idris (2014) is also of the view that grouping students based on ability can be done at random or in some systematic ways. WAEC (2003), as cited by Idris (2014) recommended one of these systematic ways by forming ability groupings based on WAEC performance grades as follows:

A_1 and B_2 (75-100 and 70-74) as high ability students

B_3 (65-69), C_4 (60-64), C_5 (55-59), and C_6 (50-54) as medium ability level students

D_7 (45-49), E_8 (40-44) and F_9 (0-39) as low ability students

Idris (2014) added that each of these ability levels can be determined by the achievement of students based on continuous assessment grades or other achievement test scores.

In addition, Lakpini (2007) recommended that ability levels can be determined as follows:

Top 25% are regarded as high ability level

Middle 50% as medium ability level

Bottom 25% are regarded as low ability level

In addition, Isa (2014) worked on impacts of co-operative learning strategy on performance and retention in geometry among JSS students in Sokoto metropolis and used pre-test scores to put subjects into mixed ability groups.

The present study also used pre-test results to place students into various ability levels and form heterogeneous groups. This is because the test is a validated test and administered by the Researcher, unlike the terminal examinations of the selected schools whose validity and method of administration is unknown to the researcher.

2.5.3 Roles of the Teacher in Co-operative Teaching Strategy

For smooth group work in a co-operative learning class, Colorado (2007) advised that it is important to establish classroom norms and protocols that guide students to contribute, stay on the task, help and encourage each other, share ideas, solve problems and give or accept feedback from peers. However, to implement any method of teaching successfully, the teacher must know his roles very well.

The roles of a teacher in any co-operative learning lesson can be summarized into three (3) major roles. These, according to Omoike, Oviawe and Ibhafidon (2008) are:

- Presenting materials to the students: Let the students know exactly what they are to do, in what order, with what materials and when appropriate.

- Monitoring students' progress in groups: Here, the teacher monitors students' interaction in the groups, provides assistance and clarifications as needed. Make the students aware that all the group members must contribute and no one should take over the group.
- Re-enforcing the occurrence of collaborative behaviors: The teacher can ask questions to re-direct group work, provide additional instructions to some students struggling with a task. The teacher also uses verbal praise to reinforce students or groups working collaboratively to solve problems.

However, in carrying out these roles, the teacher should avoid the following practices because they are strong barriers to effective co-operative learning lesson:

- Giving only group grade
- Assigning group task that requires frequent and extensive meeting outside class.
- Giving unclear direction and being lazy or negligent enough to monitor and observe students as they work in groups (Omoike, Oviawe and Ibhafidon, 2008). In support of this point, Sharan (2010) remarked that while co-operative learning is time – consuming, its success hinges on an active instructor.
- Another limitation of co-operative learning is that teachers in co-operative class may be challenged with resistance and hostility from students who believe that they are being held back by their slower group members or by students who are less confident and feel that they are being ignored or demeaned by their group members (Sharan, 2010). Such group conflicts and resistance stem from different expectations group members have for

one another. To curtail such conflicts and hostilities, Felder and Brent (2001) recommended students should prepare a list of ground rules they all agree to observe.

Researchers (Uyuota, 2006; Adikwu and Abakpa, 2010) have documented that carefully implemented co-operative learning lesson helps to increase students' performance and retention ability in mathematics and science, helps to build self-confidence in mathematics learning, prepares students for their work place in their future adult life and slow learners benefit from the heterogeneous groupings.

Despite the above benefits of using co-operative learning, studies (Okoye,2009; Okpala, 2011) showed that mathematics teachers are not aware and do not use the method during their

teaching. Therefore, the much desired, improved students' performance and retention of learning in mathematics may not be achieved if teachers are unaware and continue to avoid using innovative strategies like co-operative learning and choose to use the conventional methods. The present study is designed to compare the impacts of jigsaw II co-operative learning strategy and conventional lecture method on students' performance and retention in mensuration in order to find out what will be the outcome in the study area.

2.6 Traditional Lecture Method of Teaching Mathematics

Teaching methods can be categorized in various ways. Federal Ministry of Education – FME (2007) classified instructional methods based on:

- Degree of teacher and students' activity
- Length of existence and degree of recency

The first class is made up of teacher-centered and student-centered approaches. Lecture method and demonstration are teacher- centered while strategies like discovery, problem solving and co-operative learning are student-centered. The second class consists of traditional/conventional methods and new or innovative methods. Traditional/conventional methods include lecture, demonstration and story-telling while innovative methods include Computer Assisted Instruction (CAI), Programmed instruction and co-operative learning. From this classification, it can be deduced that lecture and demonstration methods are teacher-centered, traditional or conventional methods. This is in agreement with the view of Yusuf (2007) that traditional or conventional method of teaching mathematics is synonymous with lecture or chalk -and –talk method.

Conventional lecture method is characterized by the teacher dominating the class activities. He is considered as the reservoir of knowledge who pours it for the pupils to listen and absorb as it comes. Students remain passive and their participation is limited to listening, answering few questions and writing down notes. The method is one-directional and it limits the students' freedom to apply, analyze and synthesize the knowledge acquired. These skills, according to Adikwu and Abakpa (2010), are among the high level cognitive skills necessary for critical thinking and transfer of knowledge.

Unlike the innovative methods, traditional lecture method provides no room for the consideration of individual differences which naturally exists among learners. It also discourages teacher-learner interaction, learner-learner interaction and the interaction between learner and his

social environment which Adikwu and Abakpa (2010) described as necessary for permanent and retentive learning. Therefore, traditional lecture method encourages rote memorization of concepts which leads to quick and easy forgetting. In support of this, Benjamin Bloom, a renowned educationist, cautioned that traditional lecture method is a waste of resources as only 30% of learners benefit from it (FME, 2007).

The above description shows that traditional lecture method is ineffective. Despite its lapses, mathematics teachers are known to be widely using the method in their classes. Azuka (2009) revealed that over 90% of the mathematics teachers surveyed in his study agreed that they used lecture method in their teaching. Also FME (2007) noted that the traditional lecture method, though viewed as out-dated, is one of the methods widely used in secondary school classes as well as post-secondary institutions. Other researchers in mathematics education who confirmed the popularity of traditional lecture method among secondary school teachers are Bolaji (1999), Omoike, Oviawe and Ibhafidon (2008) and Adewumi (2012). The possible reasons for this

popularity are: the method allows quick coverage of syllabus, consumes less time and can be used to teach large class. However, FME (2007) is of the view that lecture method can be incorporated to supplement co-operative learning lessons. It can be used to make initial presentation of materials and give clear directions to groups. Prescott (1993), in Omoike, Oviawe and Ibhafidon (2008), expressed the same opinion when he argued that co-operative learning does not have to eliminate lecture method but it can co-exist with lecture method.

The present study was designed to compare the impacts of jigsaw II co-operative learning strategy with the traditional lecture method to determine which method improves performance and retention ability more than the other.

2.6.1 Instructional Delivery Using Traditional Lecture Method

In traditional lecture method, the teacher verbally delivers a pre-planned body of knowledge to his students. The teacher talks while the students listen attentively and jot down points. In some cases, the teacher may not take questions from the students. Sometimes, he entertains questions either to emphasize some points or to make some points clearer. Adikwu and Abakpa (2010) maintained that using traditional lecture method is characterized by working the previous assignment, presenting the day's lesson, giving class work from textbooks, everyday homework and occasional testing. FME (2007) suggested what is required of a teacher using lecture method at the three (3) crucial parts of lesson delivery:

- Introduction: This should be as interesting as possible. It can be in form of short story, a statement, a question or any activity that will stimulate the students to listen to the lesson.
- Presentation: The teacher needs to display a good command of language in order to present materials successfully. Points to be taught should be presented in a sequential and inter-related manner to aid understanding and recall. Repetition for emphasis and clarity is allowed. However, care should be taken to avoid too much repetition as this may cause the students not to listen the first time. Periodic humor and use of appropriate examples in the presentation are important in reducing the strain of following the lecture.

- Conclusion: The teacher could summarize the points taught or emphasized. It is helpful to give references for further reading or other forms of assignment to reinforce learning. The students also copy the points made which are usually written down on the board.

2.7 Teaching and Learning Geometry in Secondary School

Geometry is a branch of mathematics that studies space and spatial relationship. It is contained in mathematics curriculum at all grade levels. Geometry is a way of reasoning and a system of representation that is used to conceptualize and analyze physical and imagined spatial environment. Choi (2013) stressed the importance of geometry when he said that it offers ways to interpret and reflect on our physical environment which help students to link geometrical theory to their daily lives. Further, Hassan (2010) buttressed this point when he said that ability to apply geometric concepts is a life skill used in many occupations. Therefore, it can be said that in order to perform well in one's chosen occupation for meaningful self and community development, knowledge and application of geometrical concepts is very important. In fact, learning of other aspects of mathematics can be enhanced by learning geometry. This is because geometrical illustrations are helpful to students in the understanding of other mathematical topics.

However, as important as geometry is to the development of an individual and his society, performances in the area have continued to decline. The report of WAEC chief examiner (1998) pointed out that mathematics continued to be dreadful to candidates in the area of geometry and geometrical drawings and their interpretations. The report further lamented that candidates' responses to questions on geometry reflected their weaknesses in geometry compared with other

aspects of mathematics. As a remedy, the report suggested that candidates should form study groups to exchange ideas and intuitively develop in themselves the concepts of inquiry. This implies that learners' working in groups as provided in co-operative learning is seen as a solution to students' problems in geometry.

This poor trend in learning geometry continued unabated as the Chief Examiner's Report WAEC (2005) revealed that students had problems in the geometric area of mathematics and such problems have been traced to lack of visualization and spatial skills. Hassan (2010) argued that development of visualization and spatial skills can be achieved through the use of combination of one's senses in learning a geometrical concept. Of course, jigsaw II co-operative learning involves the use of learners' senses to construct their own knowledge.

Similarly, Awotunde and Bot (2003) reported that students are known to record very poor performance in both internal and external examinations with greater deficiencies in geometry. This ugly trend also affects students in JSS classes. Obioma, cited by Awotunde and Bot (2003), found deficiency profiles of JSS students highest in geometry and statistics. This shows that geometry makes the least impression on students. As such, they avoid learning it and even if they make attempt, they fail.

Difficulty in learning geometry is not only evident among Nigerian students. Studies conducted by Ginsburg (2005) in Choi (2013) showed that 15-year old American students performed least in the space and shape (Geometry) aspects when compared with other content domains (algebra, numbers and operations and probability and statistics) in Program for

International Students' Assessment (PISA). Geometry was also found as their weakest area in Trends in International Mathematics and Science Study, TIMSS, (2003).

On the geometrical concepts students have difficulties, studies on geometry learning among age groups, as cited by Abbas (2008), showed that both 13 and 17 year old students were unable to solve problems on similarity of triangles while students within the age range 12 – 19 have difficulty with naming similar triangles. This indicates that students at both JSS and SSS have problem in understanding the geometrical concept of similar triangles. Further, previous researches (Choi, 2013) on geometry education showed that formal proofs and theorems are the most difficult topics in geometry. Not only these topics, Awotunde and Bot (2003) mentioned angles, properties of plane shapes, loci, mensuration, construction and the solution of
3- Dimensional problems as areas of students' weaknesses in geometry. Hassan (2010) also revealed that students find it difficult to accurately measure, construct draw and even re-arrange objects, which are basic processes involved in the study of geometry. Other identified areas of weaknesses among students are longitude and latitude (Nigeria Educational Research and Development Council- NERDC, 2012) and surface areas and volumes (National Mathematical Centre – NMC, 2006; Idehen, 2012, NCCE, 2012). Specifically, NCCE (2012) listed volumes and areas of solid shapes (cubes, cuboids, cylinders, cones and pyramids) as well as volumes and areas of similar shapes among the difficult areas that should be taught to prospective mathematics teachers as a course of study in NCE mathematics programme. Further, Musa and Bolaji (2015) revealed that WAEC Chief Examiners' Report (2003 -2012) consistently revealed candidates' lack of skill in answering questions in geometry of 3-dimensional shapes. Similarly, Sam-Kayode and Salman (2015) in their study which aimed at identifying conceptions of geometry held by senior secondary school students in Ogun State, Nigeria, reported that students

had difficulty in mensuration as they discovered that the proportion of students who held misconceptions on some mensuration concepts were more than the proportion of students holding correct conceptions. This clearly showed that mensuration aspect of geometry remains a difficult area among senior secondary school students.

Researchers have attempted to provide empirical evidence on reasons why students perform poorly in geometry. Lassa (1986) was of the view that one of the main problems of teaching geometry in secondary schools is that teachers themselves lack adequate understanding and competence to handle topics in geometry. Due to this, many teachers skip or avoid geometry content of mathematics curriculum. This causes an irreparable loss to the child's geometric knowledge in future. To overcome this problem, Fajemidagba (1992), in Abbas (2008), suggested that teachers should learn more geometry to improve their students' learning outcomes in the area.

Another possible obstacle which hinders effective teaching and learning of geometry is the fact that students do not understand the vocabulary and terminologies associated with geometrical concepts and skills. This means that there is a great problem in understanding mathematical language used in teaching geometry. Ebisine (2012) rightly noted that problems in mathematics instruction are related to language. To curtail such problems, Inekwe (1998) advised that teachers should spend time to explain concepts and terminologies associated with geometrical proofs to reduce semantic problems. Elaboration is one of the fundamentals on which co-operative learning is based.

Scholars have also identified some skills that are required for success in geometry but students and their teachers are known to be deficient in these skills. For instance, Bolaji (1999), in Inekwe (2003), found that proportional reasoning, a required competency in geometry, was

deficient not only among students but also among pre-service and in-service mathematics teachers. Also WAEC (2005) pointed out that students lack visualization and spatial skills. Visualization skill allows human to discriminate and interpret the visible action or object or symbol that they encounter in their environment. It also aids active reconstruction of past visual experiences. On spatial skills, Awoniyi (2002) concluded that differences in spatial ability accounted for variation in educational pursuit and achievement in mathematics tasks. Still, Inekwe (2003) identified lack of logical reasoning skills as the major hurdle to sound thinking and correct proof among secondary school students.

In all, use of inappropriate instructional strategy remains a major problem of teaching and learning geometry. Researchers have attested to this viewpoint (Dambatta, 2008; Kurumeh, 2006). Specifically, Inekwe (2003) stressed that the magnanimity of students' geometrical difficulties is a strong curriculum and pedagogical problem which needs mathematics educators' attention.

Based on the above, the present study was designed to investigate the impacts of jigsaw II co-operative learning strategy on secondary school students' performance and retention in some mensuration concepts in geometry when compared with the conventional lecture method.

2.8 Jigsaw II Co-operative Learning and Retention Ability in Geometry

Many students turn out to be in confusion after discovering that they can no longer recall what they were taught. The term 'retention' is used to refer to the ability to recall or recognize the concept which has been learnt before (Gubbad, 2010). To Bichi (2000), retention is the ability to keep and consequently remember materials experienced or learnt by a person at a later time. According to Archie (2000), retention can be seen as the persistence of learned material

over a period of time which can only be reflected in an individual's ability to recall or remember. These definitions show that retention is achieved when a learner can reproduce what has been learnt at a later period which can be short or long interval. Kundu and Tutoo (2002) described the process of retention as a preservative factor of the mind. To them, for retention to occur, the mind acquires the material of knowledge through sensation and perception. The acquired material in the mind needs to be preserved in forms of images. Whenever a stimulating situation occurs, retained images are reproduced to make memorization possible. Based on the above procedure for making retention possible, Chianson, Kurumeh and Obida (2010) emphasized that mathematical concepts (geometry inclusive) need to be presented to the learners in a method that touches their sub-conscious which can trigger quick recall. To further emphasize the importance of appropriate teaching method in enhancing retention of learning, Uyuota (2006) remarked that if concepts learnt must be retained for problem solving, then, careful consideration must be given to methods by which subject matter, the learner and the teacher will interact. Such interaction will obviously involve all students using their senses actively. This probably made Newcomb et al (1998) in Kajuru and Popoola (2010) to conclude that an individual learner retains 10% of what he read alone, 20% of what he heard, 30% of what he saw and heard while the percentage increases for those who read, see and do things in a

practical situation. This clearly shows the relevance of instructional strategy and learning environment in determining how much is retained.

Jigsaw II Co-operative learning is a strategy that can assist students to retain geometrical concepts. This is because it is a strategy that depends on learner – learner, learner-teacher and learner- material interaction to accomplish learning task. It is also a strategy which permits all students, regardless of their ability, background and exposure, to participate in small group

activities using their senses to solve a challenging task. Inekwe and Hassan (2002) are of the view that for improved retention of geometrical concepts, geometrical environment should be brought into the classroom instead of verbal explanation of such concepts. Hence, the geometry teacher using jigsaw II co-operative learning is only a facilitator who allows his students to touch, see, measure and compare the various geometrical figures found in the geometrical environment created in the classroom.

Furthermore, literature suggests that materials that have been over-learnt or studied beyond the point where they can be repeated correctly are better retained than materials learnt in a rote manner. Abbas (2008) opined that over-learning is actualized when teaching geometry through approaches that have link with problem-solving. Adikwu and Abakpa (2010) documented that co-operative learning is one of the approaches that have direct link with problem-solving but in small groups set-up and the strategy reduces the low achievers' insecurity about problem – solving in mathematics. In their effort to solve problems in a jigsaw II co-operative teaching set-up, students of varied ability consistently elaborate and explain a topic to group members which

brings about complete retention of the topic. Such elaboration is done based on various portions of a topic and at two stages i.e expert group and jigsaw group.

Researches cited by Abbas (2008) have attributed students' perceived poor retention of geometrical concepts to the gap between the teachers teaching the subject and students' level of understanding. Therefore, the geometry teacher should consider his students' age, intellectual ability, etc, in preparing and delivering his lesson. In this regard, the theory of the development of geometry thinking proposed by Van Heile, in Abbas (2008), should be borne in mind so that students can move from one level to another successfully. Carpenter, in Hassan (2010), noted

that all the activities in Van Hiele's levels should be carried out through class discussion based on students' observations and hypotheses. These processes are all embedded in a well - organized jigsaw II co-operative lesson. Other studies have also pointed that some factors enhance retention while others inhibit retention. Therefore, a geometry teacher using jigsaw II co-operative learning must take note of those factors. In the lesson, factors for retention should be reinforced while factors against retention should be avoided. Azuka (2012) mentioned some factors or techniques that enhance retention of mathematical concepts to include:

- Avoiding interference /inhibition effects
- Use of instructional materials
- Use of active learning strategies
- Provision for individual differences
- Over mastering of concepts by consistent elaboration

A critical examination of jigsaw II co-operative learning strategy reveals that all the above techniques are employed in order to assist learners to construct their new knowledge from past experiences. Thus, the researcher felt that jigsaw II co-operative learning strategy is likely to improve retention of geometric concepts among secondary school students.

At this point, it is worthy to note that when students are learning under similar environment, using the same educational media and methods, gender difference can be another factor that may affect students' performance and retention in geometry.

2.9 Gender and Performance in Mathematics

It has been observed that girls do not participate fully in courses like mathematics, engineering and physical sciences which are still male-dominated. Ebisine (2010) specifically

observed that majority of girls no longer study mathematics and those who do, continue to attain lower performance scores compared to boys. This trend can inhibit the creativity of womenfolk. This might be the reason why goal (3) of the Millenium Development Goals (MDG) seeks to eliminate gender disparity in our educational system.

Researchers have advanced reasons for gender disparity in the study of mathematics. Okpala and Onocha (1998) blamed poor method of instruction. Other reasons are girls receive differential treatment from boys (Kauru, 2010), culture, religion and parental influence (Amali, Ojogbane and Akume, 2004) and stereotypical attitudes (Harbor-Peters, 2005).

Various studies have been carried out on gender and gender-related issues. One area that continues to draw the attention of mathematics educators is the issue of gender differences in

mathematics performance and retention. Some studies found that boys perform better than girls especially in higher-order knowledge (Alfa, 2007; Fajemidagba and Sulaiman, 2012). Others found girls out-performing boys (Jahun in Inekwe, 2003). Yet, others established no significant difference in mathematics performance between males and females (Yusuf, 2014; Usman and Nwoye, 2010). For instance,Yusuf (2014) investigated the effects of CAI on learning of fraction among JSS students in Zamfara State, Nigeria. Results indicated no significant gender difference in students' performance when exposed to CAI. This contradicts Haruna (2012) and Auwal (2012) who revealed that boys performed better when taught using CAI. Still, others claim that the largest difference between boys' and girls' performance lie in the affective domain i.e attitude (Benson,1997). This contradicts Bolaji, cited by Abbas (2008), who argued that gender difference exists in both cognitive and attitudinal areas.

In geometry, the debate on gender-related differences in performance and retention is still inconclusive. Madu and Hogan-Bassey (2010), in an attempt to identify item response pattern in a mathematics test between males and females examinees, reported that items in algebra, geometry, trigonometry, number and numeration and problem-solving favor males while items in statistics and probability seem to favor females. To Inekwe (2003), proportional reasoning abilities in geometry differ between the two sexes in favor of girls but no significant difference in geometric logical reasoning. However, Bolaji (1999), in Inekwe (2003), identified proportional reasoning as a required competency in geometry and algebra. If girls will perform better than

boys in proportional reasoning, then, logically, they will also perform better than boys in geometry which contradicts Madu and Hogan- Bassey (2010).

The issue of sex difference in geometry was also examined based on types of schools (single or mixed). Hassan (2010) reported that girls' schools performed better than boys' schools and mixed schools in visual perception ability and skill in geometrical shapes. Also, performance of girls in mixed school was below that of girls in single sex girls' school. Therefore, he postulated that girls in an environment of their own perform well, academically. Based on this, Hassan (2010) concluded that gender differences in geometry performance were neither as marked nor always in favor of males but can be possibly attributed to the community in which the students stay. This shows that females can perform well if separated from boys.

Studies were conducted to investigate the effects of teaching methods on performance and retention of geometry concepts by gender. Olson (2002) found females out-performing males when taught mathematics by co-operative learning. But khairulanuar, Nazre, Sairabanu and Norasikin (2010) found gender difference in favour of males when exposed to co-operative learning. On the other hand, findings of Chianson, Okwu and Kurumeh (2010), Keramati,

Tahmasbi, Rafat and Khashab (2011) as well as Gambari, Shittu and Taiwo (2013) all showed that gender had no effect on academic performance of students in co-operative learning. Okafor and Adeleye (2012) found that females performed better when taught using Personalized System Instruction in Anambra State of Nigeria. This agrees with the results of Kurumeh (2006) who reported a significant difference in the performance of male and female students in favor of females when taught geometry and mensuration using ethno-mathematics approach. He

attributed the difference to the fact that women are wonderful in mathematics when exposed using familiar environment.

However, some studies found boys superior in performance in geometry. The findings of Haruna (2012) showed that boys performed significantly better in geometry when exposed to Computer Assisted Instruction (CAI). This result is in line with that of Abbas (2008) which indicated that boys achieved higher than girls in geometry when taught using problem solving but no significant difference in the mean retention scores.

Other studies still revealed no significant difference in the performance of males and females in geometry. Adaramola (2012) revealed no significant gender difference in geometry achievement when males and females with dyscalculia were taught solution of triangles using concept mapping strategy. Similar result was established by Chiason, Okwu and Kurumeh (2010) who proved empirically that boys and girls taught geometry using co-operative learning achieved equally as no significant gender difference in achievement was found (mean of males = 31.7241 while mean of females = 33. 5632). These results supported earlier findings of Awotunde and Bot (2003) which also showed that mastery learning is gender-friendly since there was no significant difference in the achievement of boys and girls in geometric construction.

From the above findings on gender, it can be seen that there are fluctuations with regards to gender performance in mathematics generally and geometry in particular. Therefore research on gender and geometry learning is still inconclusive.

In view of the above, the present study attempted to investigate whether or not boys and girls will achieve and retain equally in mensuration aspect of geometry when taught using jigsaw II co-operative learning strategy. This will contribute in the resolution of gender performance debate in mathematics.

2.10 Overview of Related Studies

A review of related literature has shown that scholars have conducted empirical researches on the impact of co-operative learning on students' learning outcomes, retention, attitudes and many other variables. These researches cut across various subject areas.

Isa (2014) worked on the impacts of co-operative learning strategy on performance and retention in geometry among junior secondary school students in Sokoto metropolis.. The design was quasi experimental. Pre-test results were used to put students into mixed ability groups. The sample size was 266 JSS 3 students selected from a population of 3137 students by using purposive sampling. Two co-educational schools participated in the study. Experimental group was taught construction by cooperative learning while control group were taught by lecture method for 5 weeks. The instruments used include Construction Geometry Performance Test (CGPT) and Geometry Retention Test. CGPT was a multiple choice test with 4 options. The reliability of CGPT was 0.63 from Guttmen split-half method. Data was analyzed using t-test. Results showed that students taught by co-operative learning had a higher performance score and higher retention score more than the control group taught by lecture method. As for gender, males taught by co-operative learning performed better than females taught using lecture method. In terms of retention, females of control group exposed to lecture method performed better than males exposed to co-operative learning strategy. The study recommended the

provision of enough time for wider classroom discussion in mathematics lessons. Isa's study is related to the present work as both deal with the impact of co-operative learning on performance and retention in mathematics. However, the present study is different from that of Isa (2014) in location, level and geometry concept examined. Isa (2014) worked on construction while the present study worked on mensuration concepts.

In a research conducted by Zakaria, Solfitri, Daud and Abidin (2013), a co-operative learning group that used jigsaw II version (experimental group) and traditional lecture method group (control group) was examined. The design was quasi-experimental. The purpose of the study was to determine the effects of co-operative learning on SS 3 students' achievement and perception concerning co-operative learning in mathematics in Pekanbaru, Indonesia. The sample consisted of 61 students. The instruments used were Mathematics Achievement Test (MAT) and open-ended questionnaire on co-operative learning. The MAT was analyzed using t-test while the questionnaire was analyzed using content analysis. Results showed that co-operative learning group achieved significantly better results than the traditional group. Also, students in the co-operative group were able to increase their understanding and to develop self confidence more than the traditional group. Both the study of Zakaria et al. (2013) and the present study worked on effects of jigsaw II co-operative learning on achievement. On the other hand, they are different in location. Also, the present study worked on retention of mensuration concepts, in addition to performance, while Zakaria et al (2013) studied perception of students concerning co-operative learning in addition to students' achievement.

Keramati, Tahmasbi, Rafat and Khashab (2011) worked on co-operative learning and students' achievement in algebra. The study was conducted among 3rd grade secondary school students in Mary-Disht City, Iran. Findings revealed a significant effect of co-operative learning on students' achievement in algebra concepts more than the traditional method. It also indicated that co-operative learning has similar effects on achievement of males and females. This implies that co-operative learning is gender-friendly. Both the study of Keramati et al (2011) and the present study worked on effects of co-operative learning on achievement. On the other hand, Keramati et al (2011) conducted their study in Iran while the present study was conducted in Kano state, Nigeria. Also, apart from studying effects of jigsaw II co-operative learning on performance, the present study worked on retention of mensuration concepts while Keramati et al (2011) worked on algebra and did not study retention of learnt concepts.

Studies on co-operative learning in Nigeria have also been carried out. Gambari, Shittu and Taiwo (2013) investigated the effects of Computer Co-operative Instruction (CCI) using Jigsaw II on SSII students' performance in algebra in Minna, Niger State. The design was pre-test-post-test control group. The Sample was made up of 60 students drawn from 3 public secondary schools in Minna. Findings revealed that CCI group outperformed both Individualized Computer Instruction group (ICI) and the lecture group. However, in terms of gender performance, the study showed that there was no significant difference between males and females exposed to CCI and ICI. The study of Gambari, Shittu and Taiwo (2013) is similar to the present work since both used jigsaw II co-operative learning to determine its impact on performance. But, they are different in location and sample size. Also the focus of the present study was on mensuration while that of Gambari, Shittu and Taiwo (2013) focused on algebra.

Chianson, Okwu and Kurumeh (2010) investigated the effects of co-operative learning strategy on SS 2 students' achievement in geometry in Benue State, Nigeria. The study adopted quasi-experimental design and tested two hypotheses. The sample was made up of 179 boys and 179 girls selected from 6 schools in 3 local government areas. The experimental group had 174 students who were exposed to co-operative learning strategy while 184 students randomly assigned to control group and exposed to traditional lecture method. Circle geometry was taught for five weeks. The instruments include Pre- GAT, used as covariate measure, and Geometry Achievement Test (GAT) constructed by the researchers with reliability coefficient of 0.73 from Cronbach - Alpha method which served as the post-test. Data analysis using ANCOVA revealed that the experimental group performed significantly better ($\overline{X}$ = 32.64) than the control group ($\overline{X}$.= 25.68). It also indicated that there was no significant gender difference in students' achievement when taught using co-operative learning. The study recommended that additional researches be conducted to increase the generalization of the findings and such further studies should focus on gender achievement differences. This result is consistent with the findings of Udousuro (1999) that students' gender does not have effect on students' performance in mathematics problem solving. Both the study of Chianson, Okwu and Kurumeh (2010) and the present study worked on effects of co-operative learning on achievement. On the other hand, Chianson, Okwu and Kurumeh (2010) carried out their study in Benue state, Nigeria while the present study was conducted in Kano State, Nigeria. Also, apart from studying effects of jigsaw II co-operative learning on performance, the present study worked on retention of mensuration concepts while Chianson, Okwu and Kurumeh (2010) worked on circle geometry and did not study retention of learnt concepts.

Other researches focused on retention of learnt geometry concepts. Chianson, Kurumeh and Obida (2010) selected two intact classes from 6 co-educational schools in Benue state, Nigeria, using simple random sampling. The study adopted quasi-experimental design. The

sample was made up of 179 boys and 179 girls selected from 6 schools in 3 local government areas. The experimental group had 174 students who were exposed to co-operative learning strategy while 184 students were randomly assigned to control group who were exposed to traditional lecture method. Circle geometry was taught for five weeks. Retention test was administered four weeks after the post- test. The retention test contained 20 multiple choice questions with 4 options constructed by swapping the questions of post-test. Findings showed that there was a significant difference in retention of circle geometry concepts between the co-operative learning group and the lecture method group in favor of the students exposed to co-operative learning. The study recommended further studies on retention of geometrical concepts using co-operative learning. The study of Chianson, Kurumeh and Obida (2010) is similar to the present work since both worked on impact of co-operative learning on retention, but, they are different in location. Also the focus of the present study was on mensuration while that of Chianson, Kurumeh and Obida (2010) focused on circle geometry and did not study performance as a variable.

Gubbad (2010) worked on the influence of co-operative learning on students' achievement and retention of mathematics concept among 6^{th} grade primary school pupils in Holy Makkah, Saudi Arabia. The design was quasi-experimental. The experimental group was taught decimal fraction concept using co-operative learning while the control group was exposed to lecture

method. The sample was made up of 59 students (30 in experimental group and 29 in control group). The experiment lasted 4 weeks, after which post-test was administered to both groups. Thirty days after post-test, retention test was taken by both groups. The reliability of the achievement test used as research instrument was 0.91 from split half method. T-test analysis showed that the experimental group achieved higher than the control group in both achievement

and retention tests. The study recommended further research on the role of co-operative learning in other branches of mathematics. The present study is different from that of Gubbad (2010) interms of level and the fact that this work dealt with mensuration while Gubbad worked on decimal fraction.

In Pakistan, Iqbal (2004) conducted an experimental study using 2x2 factorial design. One of the purposes of the study was to determine the effects of co-operative learning on achievement and retention of mathematics concepts among government high school students in Rawalpindi district. Sample size was 56 students with 28 students in the experimental group and 28 students in the control group. Experimental group was taught using Students- Team – Achievement – Division (STAD) model of co-operative learning while the control group was taught using the traditional competitive learning. The experiment lasted 10 weeks, after which post-test was administered. Retention test was administered 6 weeks after the post-test. Data analyzed using t-test showed that statistically significant difference was found between the experimental and control group in favor of the co-operative learning group. However, in terms of retention, there was no significant difference between the two groups (experimental group $\overline{X}$= 39.46 and control group $\overline{X}$= 34.8). The study further established the fact that co-operative learning benefit low

achievers more than the traditional approach as the low achievers in the experimental group outscore low achievers in the control group. Iqbal (2004) used STAD model of co-operative learning while the present study used jigsaw II co-operative learning, although both studies focused on achievement and retention.

Other studies examined the impact of co-operative learning on academic performance, retention and attitude towards mathematics. For instance, Abdulrahim and AL-Shakili (2005) used experimental design to measure the effectiveness of co-operative learning in comparison to traditional method among secondary school students in Omani, Kuwait.. The design used was quasi-experimental. Students took post- test after the experiment and were presented with a scale to measure attitude. Three (3) weeks after post-test, retention test was administered. Analysis of data using t-test showed that there was no significant difference in the mean score of students exposed to co-operative learning and those taught using traditional method in both achievement test and retention test. But attitude scale analysis revealed a significant difference in attitude towards teaching method in favor of co-operative learning.

Moore (2005) explored the effects of co-operative learning calculus program on first year non-Asian minority engineering students. The objective of the study was to ascertain the collegiate mathematics achievement of under-represented minority students. Findings revealed that the co-operative learning calculus program significantly improved academic achievement and retention rates of colored freshmen engineering students. The study of Moore (2005) was on calculus and at tertiary level while the present study worked on the mensuration aspect of geometry.

Johnson and Johnson (2002) also showed that co-operative learning was more potent than competitive or whole class teaching in promoting students' achievement in science subjects. The study concluded that with the use of co-operative learning, students realize that mathematics is a real and interesting subject rather than being an abstract and difficult one that is meant for the gifted and talented children.

Springer, Stanne and Donovan (1999) carried out a meta-analysis of the effects of small group co-operative learning on undergraduates' achievement, retention and attitudes in science, mathematics, engineering and technology (SMET) program from the year 1980. The analysis of data showed that various forms of co-operative small group learning were effective in promoting greater academic achievement, retention and more favorable attitudes towards learning. The study recommended more widespread implementation of small group learning in undergraduate SMET program and other levels. This result agreed with that of Slavin, cited by Johnson and Johnson (1994), which concluded that co-operative learning produces greater students' academic achievement than traditional methodologies as 63% of the co-operative learning groups analyzed had an increase in achievement. Also, low achieving students tend to work harder with higher achieving students.

Mevarech (1985) compared co-operative learning and mastery learning in his work involving 5^{th} grade pupils (N=134). The study used 2x2 factorial design. Findings revealed a higher achievement gain for pupils exposed to co-operative learning more than those exposed to traditional instruction. However, the results proved that learning in small groups promoted only computational skills whereas mastery learning improved both computation and comprehension

skills. This is in addition to the finding that co-operative learning benefitted low - ability students most.

Co-operative learning was also extensively studied in other subject areas. Dheeraj and Kumari (2013) investigated the effects of co-operative learning on achievement in environmental sciences among secondary school students in Gaya district, Bihar, India. The design was a randomized two-groups- post-test. The sample was 60 students. The experimental group had 30 students divided into 6 co-operative learning groups. Achievement test and attitude scale were the instruments used. Data analysis using t-test showed that the mean achievement of experimental group (42.8) differs significantly from that of the control group exposed to

traditional lecture method (38.0). Analysis of attitude scale using chi-square indicated that learning was joyful under co-operative learning method. The work of Dheeraj and Kumari (2013) and the present work investigated the effects of co-operative learning on achievement but differ in the subject studied.

Gambari, Olumorin and Yusuf (2013) worked on the effects of computer supported jigsaw II co-opearative learning strategy on the performance of SSS students in physics in Niger State, Nigeria. The study sample was 80 students (38 in the experimental group and 42 in the control group). The sample was obtained by multi-stage sampling technique. Physics Achievement Test (PAT) and Physics Attitude Scale (PAS) were the instruments used. PAT contained 100 multiple choice items adopted from WAEC past questions (May/June 1988-2008) and NECO past questions (2000-2007). PAT had reliability of 0.90 from KR-21 method. It was administered as pre-test and as post-test after it was reshuffled ANCOVA was used to analyze the data. Results

indicated that students exposed to Computer supported jigsaw II co-operative learning strategy performed better than those taught using Individualized Computer Instruction (ICI) as well as the lecture group. Further, the findings of the study showed that computer supported jigsaw II group had more positive attitude to physics than ICI group. On gender, the study revealed that there was no significant difference between males' and females' performance in physics when taught using Jigsaw II computer supported co-operative learning instruction.

Other studies that empirically proved that jigsaw II is more effective in enhancing performance among students more than individual and conventional lecture methods in other subject areas include those of Moreno (2009) in biology and Doymus (2008) in chemistry. Contrary to these findings are the results of Thompson and Fledger (1998) and Arra, D'Antonio and D'Antonio (2011) cited in Gambari, Olumorin and Yusuf (2013) that found no significant difference in the achievement of students taught using jigsaw II and those taught using

conventional classroom and discussion methods and students' negative attitude towards learning mathematics in group setting.

Marhamah and Mulyadi (2013) worked on the effects of jigsaw cooperative learning strategy on achievement in the concept of teaching learning strategy among year II undergraduates in Islamic Education department of Islamic University of Jakarta, Indonesia. The design used in the study was quasi-experimental pre-test-post-test. The sample size was 52 (28 in experimental group and 24 in control group). The experiment lasted for 6 weeks during which experimental group were exposed to jigsaw cooperative learning while the control group was taught by group discussion strategy. An achievement test with 86 multiple choice items, whose

reliability was 0.69 from KR-20 method, was used as the instrument for the study. Independent t-test analysis showed that the experimental group had significantly greater improvement on achievement than control group. Also, undergraduates had positive attitude towards jigsaw and they believed that it promotes positive attitude and interest. The study recommended that training or workshop opportunities about jigsaw cooperative learning should be made available to teachers. The present work studied the effects of jigsaw II co-operative learning on achievement and retention in mathematics at senior secondary school level while Marhamah and Mulyadi (2013) studied the effects of jigsaw cooperative learning strategy on achievement in the concept of teaching learning strategy in Islamic Studies at tertiary level of education.

Aslan, Oral, Efe and Oner - Sunkur (2011) compared computer simulation – supported STAD model of co-operative learning with traditional method of teaching biology. The study involved eighty-one (81) 10^{th} –grade students in Turkey. An achievement test containing 31 items on photosynthesis and an attitude scale were the main research instruments. T-test analysis showed the superiority of co-operative learning over the traditional method in enhancing

achievement. However, chi-square analysis showed no significant difference in attitude between the co-operative group and traditional group. Aslan et al. (2011) used STAD model of co-operative learning to determine students' performance and attitude towards biology while this work used jigsaw II model to determine its impact on performance and retention in mathematics

In chemistry, co-operative learning was proved, empirically, to be more effective than the conventional lecture method. Abdullahi (2014) investigated the effects of jigsaw co-operative

learning strategy on self efficacy and achievement in Chemistry among concrete and formal - reasoners in colleges of education in North- West zone, Nigeria. Findings revealed that co-operative learning significantly improved academic achievement of students more than the traditional lecture method. Also, co-operative learning has effects on formal-reasoners more than the concrete reasoners. On self – efficacy, no difference between co-operative learning group and lecture method group was found. Also, there was no significant difference in terms of self efficacy between formal and concrete reasoners when exposed to co-operative learning. The co-operative learning model used by Abdullahi (2014) was jigsaw model. The subject studied was tertiary level chemistry while this study employed jigsaw II co-operative learning model to investigate its impact on mathematics performance and retention at senior secondary school level.

In economics, Van Wyk (2010) studied the effects of Team Games Tournament (TGT) model of co-operative learning on achievement, retention and attitude when compared to traditional lecture method. The design was quasi-experimental. Instruments used include an achievement test made up of items adopted from the Test of Economic Literacy (TEL) which is a standardized test of economic content, an achievement test, an attitude questionnaire and a

retention test which was administered 3 weeks after taking the achievement test. Multivariate Analysis of Covariance was used to analyze the data. TEL scores and first semester grades in elementary economics classes were used as covariates to adjust for possible pre-existing differences between the groups. Results showed that no significant difference between the groups in achievement, retention and attitude towards the two teaching methods. The co-

operative learning model used by Van Wyk (2010) was TGT model. The subject studied was tertiary level Economics while this study employed jigsaw II co-operative learning model to investigate its impact on mathematics performance and retention at senior secondary school level.

Olarewaju (2012) investigated the effects of co-operative learning strategy with models on academic achievement and retention of biology concepts among Pre-National Diploma students in Kaduna State, Nigeria. The population was all the 149 students offering Pre-ND biology from the 4 federal mono-technical colleges in Kaduna State. All the four colleges were purposively selected. The sample size was 100 students, obtained by randomly selecting 25 students from each of the college. The design used was Solomon – four experimental design. STAD model of co-operative learning was used in the study. There were two experimental groups: co-operative group with model and co-operative group without model. There were also 2 control groups: lecture with model and lecture without model control groups. Biology Achievement Test (BAT), a multiple choice test developed by the researcher, was the instrument used. BAT had a reliability coefficient of 0. 859 from KR-21 method. Data was analyzed using ANOVA at 0.05 level of significance followed by Scheffe test. Findings showed that experimental groups performed significantly better than the control groups. However, there was no significant difference in the mean achievement score of co-operative learning with model

group (mean = 30.640) and co-operative learning without model (mean =29.040). The study recommended that teachers at tertiary institutions should be encouraged to use co-operative learning strategies in teaching. The present study is different from that of Olarewaju (2012) in

terms of level and the type of co-operative learning model used. Also Olarewaju's work was in biology while the present study was done in mathematics.

In Kenya, Keraro, Wachanga and Orora (2007) studied the effects of co-operative concept mapping teaching approach on secondary school students' motivation in biology. The design was quasi- experimental non- equivalent control group. Four secondary schools from Gucha district participated in the study. The sample size was 156 2nd grade senior secondary students. Experimental group was taught by co-operative concept mapping for 4 weeks while control group was exposed to lecture method for the same duration.. Both groups were tested prior to instruction. Instrument used in the study was Students' Motivation Questionnaire (SMQ). Data was analyzed using t-test, ANOVA and ANCOVA. Results indicated that experimental group had significantly higher motivation score than control group. However, no significant gender difference in students' motivation towards learning biology was found, when taught by co-operative concept mapping. The researchers concluded that co-operative concept mapping was an effective teaching approach which biology teachers need to incorporate in their teaching. The study of Keraro, Wachanga and Orora (2007) is related to the present study because both studied co-operative learning. But, the two differ as Keraro, Wachanga and Orora (2007) worked on motivation in biology while the present study worked on performance and retention in mathematics.

Uyoata (2006) examined co-operative learning and traditional whole class instructional strategy. Eighty-two primary 5 pupils from two intact classes participated in the study. The study adopted quasi – experimental design to measure achievement and retention of science

concepts. Retention test was taken 2 weeks after the post-test. The mean achievement and retention scores of the co-operative learning group was found to be significantly higher than the traditional group. Pupils' ability to retain was linked to the opportunity they had to interact in groups. The study of Uyoata (2006) is similar to the present work since both worked on impact of co-operative learning on performance and retention . But, they are different in location. Also the focus of the present study was on senior secondary school mensuration concepts while that of Uyoata (2006) focused on primary school science concepts.

Hijazi (2003) studied the effectiveness of collaborative learning strategy in science achievement of primary 5 pupils and attitude towards collective action. The sample was 124 pupils with 67 in the experimental group and 57 in the control group. The design was quasi-experimental. An achievement test and an attitude scale were the instruments used in the study. Findings showed that collaborative learning group performed better in achievement test and showed positive attitude towards collective action more than the conventional lecture group. Hijazi (2003) studied achievement and attitude unlike the present study that studied achievement and retention. Also, Hijazi (2003) studied primary school pupils while this study worked on students at secondary school level.

Abu and Flowers (1997) worked on comparative effects of co-operative learning STAD method and non-o-operative (competitive method) on achievement, retention and attitude of high school home economics students in North Carolina, USA. The study adopted quasi-experimental design. The instruments used include achievement test whose items were adopted

from the state competency test-item bank and a retention test administered 3 weeks after the achievement test. Sample for the study comprised of 197 students randomly assigned to experimental and control groups. Multivariate Analysis of Covariance showed no significant difference in both achievement and retention scores between the co-operative learning group and the traditional non-co-operative group. Also, no significant difference was found in students' attitude towards the two teaching methods. The researchers recommended that studies be conducted in which co-operative learning would be used for a semester or even entire year to determine whether students' achievement will increase with additional experience in using co-operative learning. They also recommended that other models of co-operative learning be tried to confirm or refute their findings.

However, the findings of Abu and Flowers (1997) contradicted that of Humphrey, Johnson and Johnson (1992), as cited by Yusuf (2007), who concluded that students taught using co-operative learning learned and retained better than those taught using competitive and individual methods. Also, co-operative learning group exhibited positive attitude towards science concepts than did students in competitive and individualistic groups. This result is in line with that of Tjosvold, Marine and Johnson (1997).

Mattingly and Vansickle (1991) examined jigsaw II group (N=23) and conventional whole class group (N= 22) using two intact geography 9^{th} grade classes at a US Department of Defense high school in Germany. The study concluded that academic achievement can be improved by effective application of jigsaw II as the jigsaw II group performed better than the conventional whole class group.

2.11 Implications of the Literature Reviewed for the Present Study

The literature reviewed so far indicated that mensuration aspect of geometry remains one aspect of mathematics that students and their teachers perceive as difficult and perform very low in that area. The review indicated that use of unsuitable instructional strategies by the teachers remains a hindrance in attaining the desired improved performance and retention in geometry and mathematics in general. This implies that researchers in mathematics education should explore other innovative methods of teaching mathematics that will possibly improve students' performance and retention in mensuration. Jigsaw II co-operative learning strategy is among the effective strategies used in teaching various mathematical concepts as supported by various researches (Mattingly and Vansickle,1991; Gubbad, 2010; Gambari, Olumorin and Yusuf, 2013; Zakaria, Solfitri; Daud and Abidin, 2013).

However, majority of the studies reviewed were carried out in foreign countries. Literature reviewed indicated that no study was conducted in the study area (Kano state) on the efficacy of jigsaw II co-operative learning strategy, despite the fact that students' performances in mathematics have continued to decline in the area. Further, it showed that mensuration aspect of geometry did not receive the due attention of mathematics education researchers on co-operative learning, to the best knowledge of the researcher. Also, reviewed literature indicated that research on gender and geometry performance is yet to be concluded. Hence, the need for more studies on performance, retention and gender differences in learning geometry and mathematics in general. This study was carried out on the impacts of jigsaw II co-operative

learning strategy on performance and retention ability in Kano state, Nigeria, and focussed on mensuration aspect of geometry which has been neglected by previous researchers. Thus, the

present study is unique because it covered the mensuration area of geometry which has not been studied before by researchers who have worked on jigsaw II co-operative learning strategy.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The main objective of this study is to investigate the impacts of jigsaw II co-operative learning strategy on senior secondary school students' academic performance and retention of mensuration concepts. This chapter explained the methodology used in carrying out the investigation. This is presented according to the following sub-headings: Research Design, Population of the Study, Sample and Sampling Technique, Instrumentation, Geometry Achievement Test (GAT), Geometry Retention Test (GRT), Validation of Instruments, Pilot-Testing, Reliability of the Instrument, Administration of Treatment, Data Collection Procedure and Procedure for Data Analysis.

3.2 Research Design

Quasi- experimental, non-randomized pre-test - posttest control group design was employed in conducting the study. The choice of this design was based on the fact that it controls researcher's selection bias, since there was no randomization of the subjects into groups (Usman & Nwoye, 2010). In this design, four (4) intact classes were involved in the study. Two classes were randomly assigned to the experimental group and the other two classes to control group.

Before instruction started, both groups took a pre-test in order to establish whether the entry level of the subjects in both groups is significantly different or not. After the pre-test, the selected mensuration topics were taught to the experimental group using jigsaw II co-operative learning strategy and the control group was taught the same lesson contents using lecture method. A week after the last lesson for the two groups, a post-test was taken by both groups to measure the level

of academic performance, due to the type of instruction they received, in the learnt mensuration concepts. This was to allow students to revise the taught concepts and prepare for the post-test. Two weeks after the post-test, a retention test was administered on both groups to measure the amount of learning each group could retain. An interval of two weeks between the post-test and retention test is the minimum period recommended (Tuckman, 1975; Sambo, 2008). To control for teacher quality differences, the researcher personally taught the classes. In this study, the independent variables are teaching method and gender while the dependent variables are students' academic performance and retention. The design is illustrated in Figure 3.1:

$E_G \longrightarrow O_1 \longrightarrow X_1 \longrightarrow O_2 \longrightarrow O_3$

$C_G \longrightarrow O_1 \longrightarrow X_0 \longrightarrow O_2 \longrightarrow O_3$

Figure 3.1: Research Design

Key:

E_G = Experimental group (jigsaw II co-operative learning group)

C_G = Control group (conventional lecture method group)

O_1 = Pretest

X_1 = Treatment using jigsaw II co-operative learning strategy

X_0 = Teaching using conventional lecture method

O_2 = Posttest

O_3 = Post-posttest (Retention test)

3.3 Population of the Study

The target population comprised of the entire class one students of public senior secondary schools in Kano State. There are 499 public senior secondary schools in Kano State

spread across the 14 zonal education offices in the state. Out of the 499 senior secondary schools in the state, 299 are boys' schools and 200 are girls' schools. There are 69, 736 senior secondary one students in Kano State public secondary schools. Out of this number, 40,648 are boys while 29,088 are girls. The distribution of the population by educational zone, type of school (boys or girls) and SS1 students' enrolment by gender is presented in Table 3.1:

Table 3.1 Population of the Study

Zone	No. of boys Schools	No. of girls schools	No. of SS1 Males	No .of SS1 Females	Total no. of SSI students
Bichi	22	7	2033	816	2849
Dala	11	24	4090	5252	9342
Dambatta	28	15	3268	1962	5230
Dawakin Kudu	22	13	2986	1656	4642
Gaya	30	13	2142	1197	3339
Gwarzo	22	13	2475	1286	3761
Karaye	22	13	2499	898	3397

Kura	22	13	1640	1707	3347
Minjibir	21	17	3360	1542	4902
Municipal	16	22	4855	4246	9101
Nassarawa	17	20	5569	5526	11095
Rano	20	13	1536	874	2410
Tudunwada	28	07	1962	791	2753
Wudil	18	10	2233	1335	3568
Total	**299**	**200**	**40,648**	**29,088**	**69,736**

Source: (Kano State Senior Secondary Schools Management Board, 2014)

3.4 Sample and Sampling Technique

Multi-stage random sampling was employed to select 4 intact classes for the study. At the first stage, two (2) educational zones were selected from the 14 zones using balloting. At the second stage, two schools were selected from each of the two zones (one for boys and one for girls) using balloting. This gave a total of 4 schools (two for boys and two for girls). At the third stage, one boys' school was assigned to experimental group and the other to control group. Similarly, one girls' school was assigned to experimental group and the other to control group. This gave 2 schools (one for boys and one for girls) in each of experimental and control group. Finally, one intact class was selected from each school randomly by balloting. Therefore, the total sample for the study is 159 students with 82 students in the experimental group and 77 in the control group.. This sample is considered viable for the study because of the fact that central limit theorem recommended 30 subjects as the minimum and sufficient sample size for

experimental studies (Tuckman, 1975; Sambo, 2008). Table 3.2 shows the summary of the sample.

Table 3.2: Sample for the Study

Educational zone	Schools selected	Type of school	No. of SSI sample	Group
Tudunwada	A	Boys	40	Experimental
	B	Girls	42	Experimental
Kura	A	Boys	35	Control
	B	Girls	42	Control
Total			**159**	

3.5 Instrumentation

The researcher developed and used two instruments in this study. These instruments are:

1. Geometry Achievement Test (GAT)
2. Geometry Retention Test (GRT)

3.5.1 Geometry Achievement Test (GAT)

The researcher developed GAT. It consists of 30 multiple choice items with options A-D. Only one option is correct while the remaining three are distractors. The items in GAT are based on the selected topics covered in the experiment (surface areas and volumes of cubes, cuboids and cylinders) as contained in NERDC (2012) mathematics curriculum for senior secondary class one. Each correct answer attracted 2 marks, totaling 60 marks. Marking was done by the

researcher. This instrument served dual purposes. First, it was administered to both the control and experimental groups as a pre-test before the commencement of the experiment. This was done to establish whether the entry level of the two groups is significantly different or not. Secondly, GAT was administered to both the control and experimental groups at the end of the experiment as post-test. This was done in order to measure the impacts of the treatment each group received on their academic performance in the topics taught. The instrument and its solutions are in appendices A and B respectively.

3.5.2 Geometry Retention Test (GRT)

This instrument was also developed by the researcher. It is made up of 30 multiple choice items with options A-D. Each correct answer carried 2 marks, totaling 60 marks. Marking was done by the researcher. The items in GRT were developed by swapping the items and options in GAT. The swapping was done to prevent the effects of GAT on GRT. This instrument (GRT)

was used as post-posttest or retention test. It was administered to both control and experimental groups two weeks after taking GAT in order to measure how much was retained by both groups due to the treatments they received. An interval of two weeks was chosen based on the fact that two weeks is the recommended minimum interval between post-test and retention test (Tuckman, 1975). The instrument and its solutions are in appendices C and D respectively.

3.5.3 Validation of Instruments

The two instruments GAT and GRT were given to two experts in mathematics education, one from Northwest University, Kano and the other from Bayero University, Kano (all of them Ph.D

holders and senior lecturers by rank). The instruments were also validated by an expert in test and measurement from NorthWest University, Kano who also holds Ph. D and on the rank of Senior Lecturer. The experts commented on whether:

- The items adequately cover the topics taught
- The items test what they are designed to measure
- The questions are not above the students' ability level and are not ambiguous

Based on the comments and observations of the experts, items 3 and 9 were re-casted to make them unambiguous, while item 17 was completely removed.

3.5.4 Pilot Testing

Government Secondary School, Gabasawa in Minjibir zonal education office was selected to pilot-test the instrument. The school is in the study population but not in the sample. Thirty (30) SS1 students were selected. GAT was administered on the 30 students. The purposes of the pilot -testing were to:

- Determine the characteristics of the test items such as difficulty index and reliability coefficient
- Assess the feasibility of the study before commencement
- Determine the appropriate time to be allotted for the subjects to answer the questions.

Following the pilot-study, items with difficulty index between 0.40 and 0.60 were selected. This decision was based on the recommendation of Anikweze (2010) that test items with average difficulty index between 0.40 and 0.60 could be selected for a test that measures performance

after some period of instruction. In short, items having an average difficulty index form the final version of the instrument.

3.5.5 Reliability of the Instruments

The result obtained from pilot-testing was also used to determine the reliability index of GAT. The reliability coefficient of GAT was estimated using split half method. Upon applying Brown prophecy formula, the coefficient of internal consistency was found to be 0.74.

3.6 Administration of Treatment

Two groups were involved in the study (experimental and control groups). The experimental group was taught using jigsaw II co-operative learning strategy while the control group was exposed to the conventional lecture method

3.6.1 Treatment procedure for experimental group using jigsaw II cooperative learning

Jigsaw II co-operative learning is an instructional strategy that requires students to work in groups of 4,5 or 6 students. In this strategy, a topic is divided into sub-topics equal to the number of students in each group. Each student in a group is assigned a sub-topic and is given a learning

material relevant to his/her assigned portion of the topic to study for some moment. Members of different groups who have studied the same material meet together, to share information and solve the task. Their expert knowledge is shared with other members in the original home group. The group that excels in terms of improved performance is awarded group reward. Therefore, jigsaw II emphasizes the use of group work and reward for co-operation to achieve group goal.

The following steps were followed in teaching the experimental group using jigsaw II co-operative learning strategy:

Step 1: Formation of mixed ability groups: Teacher formed mixed ability groups of 4 students per group. This group is called home group.

Step 2: Assignment of group roles and individual tasks: Teacher distributes lesson materials, assigns group roles and a task from the expert sheet to each member of the home group. An expert sheet contains 4 questions on various sub-topics of a particular topic to be learnt.

Step 3: Review of roles responsibilities and jigsaw II procedure: Students review the roles to play by each member during group work while teacher explains the jigsaw II co-operative learning procedures.

Step 4: Reading of assigned sub-topic: Each member of home group reads his/her assigned sub-topic for some time using the reading material supplied.

Step 5: Expert group discussion: Home group members assigned the same question on the expert sheet meet to form an expert group. In the expert group, students discuss and share their ideas on the question until a solution is obtained. Teacher goes round to assist groups with difficulty, facilitate and praise collaborative work.

Step 6: Home group reporting: Students come back to their home groups to teach what they have learnt on their assigned sub-topics during expert group discussion to the remaining members of home group.

Step 7: Whole class discussion: Teacher initiates a brief whole class discussion in order to clear doubts arising from the group discussions held during the lesson.

Step 8: Evaluation: Students take an individual short quiz to test their understanding of the topic taught. The scripts are marked and scores made known to each student.

Step 9: Group recognition: Individual improvement score as well as group average improvement score for each home group is calculated by the students under the teacher's guide. The group with the highest average improvement score receives a group reward.

Step 10: Closure: The lesson ends by assigning a question from the expert sheet prepared for the next lesson to each member of the home group so that students read their assigned sub-topic as home work. This is to save the next lesson's time and for students to come fully prepared for expert group discussion in the next lesson.

The flow chart of the jigsaw II teaching strategy is illustrated in Figure 3.2

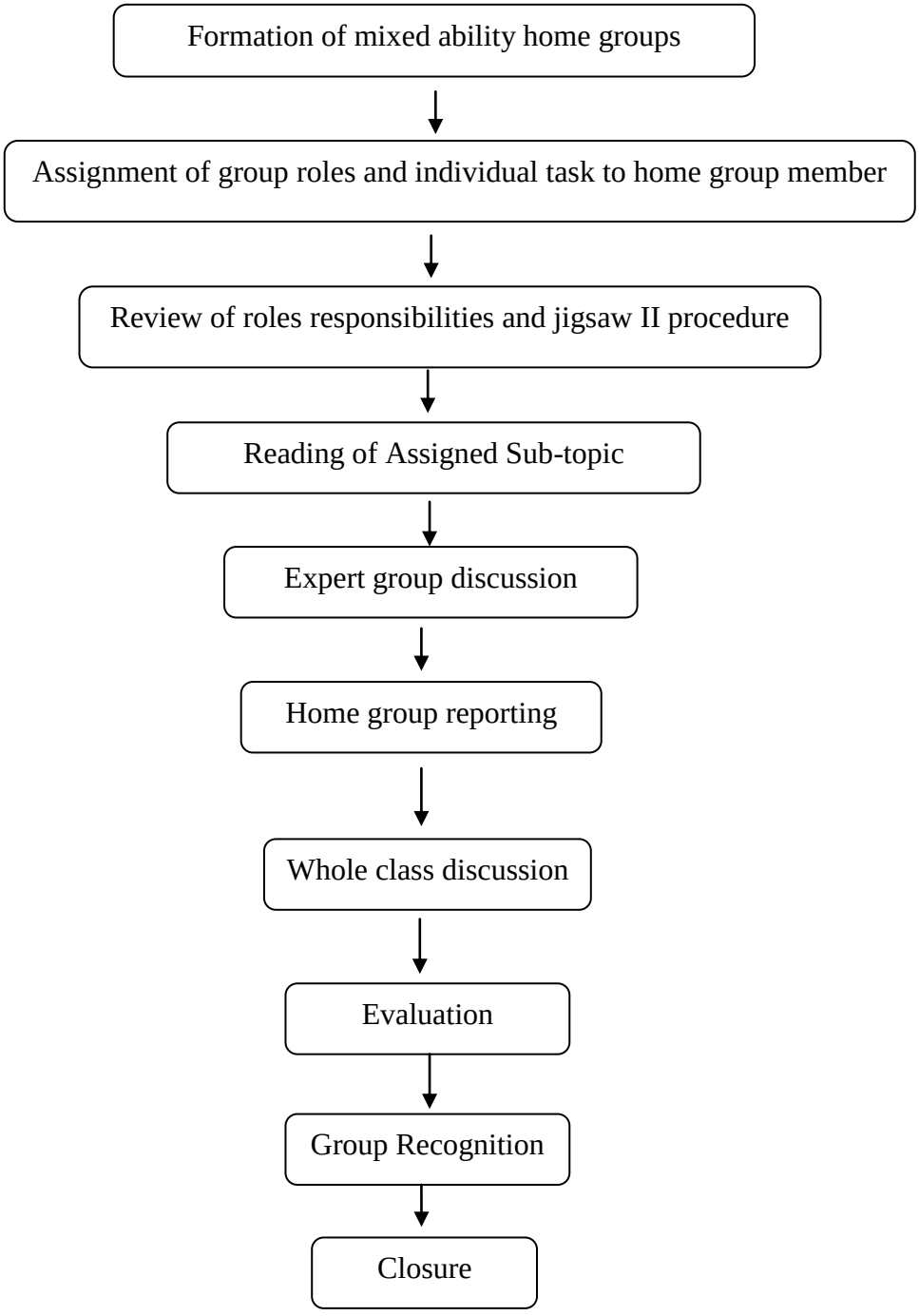


Figure 3.2: Flow chart of jigsaw II co-operative teaching strategy

Source: Adapted from Chan (2004).

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The detailed jigsaw II co-operative teaching strategy guide used in teaching the experimental group is in appendix F while the expert sheets for expert group discussions are presented in appendix G.

3.6.2 Teaching the Control Group (Lecture Method)

In each lesson period, the teacher begins the lesson by asking students few questions related to the new topic to be learnt as a form of introduction. The teacher then presents the new lesson by using students' responses to the questions asked during the introduction stage to give further explanations on the new topic. Based on the explanations given, the teacher then solves examples on the new topic while students only listen, watch and ask few questions. Lesson was evaluated by calling some students to solve some questions on the learnt topic on the board or by giving class work. Finally, the lesson was concluded by allowing students to jot down the worked examples in their notebooks. Where class work is given, the lesson ends with the teacher marking the class work and giving corrections for the students to copy in their notebooks. The detailed lesson plan used to teach the control group is presented in appendix E.

3.7 Data Collection Procedure

GAT was administered to both experimental and control groups before the commencement of the experiment as a pre-test by the researcher. Scores of pre- test was used to determine if there is significant difference in the subjects' entry level before the experiment started.

The experiment took 6 weeks for the experimental and control groups. The choice of 6 weeks was based on the recommendation of Sambo (2008) that educational experiments could take some weeks before they are concluded. The instruction time was 40 minutes per

period for 6 lessons of double periods per week. Experimental group was taught surface areas and volumes of cubes, cuboids and cylinders using jigsaw II co-operative learning strategy while the control group was taught the same lesson contents using conventional lecture method. These topics were selected because they are identified as being among those geometric areas that mathematics students have difficulty with.

After treatment, both groups took GAT as post-test. Scores obtained from post-test were used to measure performance difference, if any, due to the type of treatment received by each group. Two weeks after taking GAT, GRT was administered on both groups as post-posttest to measure retention. These tests were administered and marked by the researcher.

3.8 Procedure for Data Analysis

The data obtained from the named instruments for the study was used to answer all the four (4) research questions using mean and standard deviation as follows:

1. What is the difference between the mean performance scores of students taught mensuration concepts using jigsaw II co-operative learning strategy and those taught using the conventional lecture method?

   Descriptive statistics used in answering this question were mean and standard deviation.

2. What is the difference between the mean retention scores of students taught mensuration using jigsaw II co-operative learning strategy and those taught using conventional lecture method?

   Mean and standard deviation were used to answer this research question.

3. What is the difference between the mean performance scores of males and females when taught mensuration concepts using jigsaw II co-operative learning strategy?

   The descriptive statistics employed to answer this question were mean and standard deviation.

4. What is the difference between the mean retention scores of males and females students taught mensuration by jigsaw II co-operative learning strategy?

   Mean and standard deviation were used to answer this research question.

On the other hand, the four (4) hypotheses for the study were tested at $P \leq 0.05$ as follows:

1. $HO_{1:}$ There is no significant difference between the mean performance scores of students taught mensuration concepts using jigsaw II co-operative learning strategy and those taught using conventional lecture method.

   The statistical tool used in testing this hypothesis was independent t-test at 0.05 level of significance.

2. HO_2: There is no significant mean difference between the retention scores of students taught mensuration using jigsaw II co-operative learning and those exposed to conventional lecture method.

   Independent t-test statistical analysis was used to test HO_2 at 0.05 level of significance

3. HO_3: There is no significant difference in the mean performance scores of male and female students taught mensuration by using jigsaw II co-operative learning strategy.

   The statistical tool used in testing this hypothesis is independent t-test at 0.05 level of significance.

4. HO_4 : There is no significant difference between the mean retention scores of male and female students when taught mensuration using jigsaw II co-operative learning strategy.

Independent t-test statistical analysis was used to test HO_4 at 0.05 level of significance

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

In this chapter, data collected from the two instruments (GAT and GRT) administered as pretest, posttest and post-post-test was presented, analyzed and discussed. This was done according to the raised research questions and hypotheses in chapter one. Mean and standard deviation were used to answer all the research questions .In testing the hypotheses of the study, $\propto = 0.05$ was adopted as the level of significance and formed the basis for rejecting or retaining all the null hypotheses. The t-test statistic was used to test all the four null hypotheses. The chapter is presented in the following sub-headings:

- Data Presentation
- Data Analysis
- Hypotheses Testing
- Summary of Findings
- Discussions

4.2 Data Presentation

The data collected using the study instruments GAT and GRT was analyzed and the results obtained were used to answer the research questions and test the formulated hypotheses as follows:

4.2.1 Data on the GAT Scores of experimental and control Groups

Data on the performance scores (GAT scores) of experimental group and control group in mensuration concepts is presented in Table 4.1:

Table 4.1: Mean and Standard Deviation of Experimental and Control Groups on GAT

Group	N	$\overline{X}$	SD	Mean Difference
Experimental	82	28.54	5.72	9.04
Control	77	19.50	4.32	

The results in Table 4.1 showed that the experimental group exposed to jigsaw II co-operative learning had a mean of 28.54 with standard deviation of 5.72 while the control group taught using lecture method had a mean of 19.50 with standard deviation of 4.32 in the GAT. Therefore, the difference between the mean performance score of the experimental

group exposed to jigsaw II co-operative learning and control group taught using conventional lecture method is 9.04.

4.2.2 Data on the GRT Scores of experimental and control Groups

Data on the retention ability scores (GRT scores) of experimental group and control group in mensuration concepts is presented in Table 4.2:

Table 4.2: Mean and Standard Deviation of Experimental and Control Groups on GRT

Group	N	$\overline{X}$	SD	Mean Difference
Experimental	82	24.20	5.53	
				7.91
Control	77	16.29	4.88	

Table 4.2 showed that the experimental group had a mean score of 24.20 in GRT with standard deviation 5.53 while the control group had a mean of 16.29 and standard deviation of 4.88. This showed that the experimental group got a higher mean than the control group. The difference between the mean retention scores of experimental group taught mensuration concepts using jigsaw II co-operative learning and control group exposed to lecture method is 7.91.

4.2.3 Data on the GAT Scores of Males and Females in the experimental Group

Data on the performance scores (GAT scores) of males and females students taught mensuration concepts using jigsaw II co-operative learning strategy is presented in Table 4.3:

Table 4.3: Mean and Standard Deviation of Males and Females in experimental group on GAT

Group	N	$\overline{X}$	SD	Mean Difference
Males	40	27.55	6.07	
				2.02
Females	42	29.57	5.14	

From Table 4.3, it can be seen that male students taught mensuration concepts using jigsaw II cooperative learning strategy had mean performance score of 27.55 with standard deviation of 6.07 while females taught by jigsaw II co-operative learning had mean performance score of 29.57 and standard deviation of 5.14. Therefore, the difference between the mean performance

scores of males and females taught mensuration concepts using jigsaw II co-operative learning strategy is 2.02.

4.2.4 Data on the GRT Scores of Males and Females in the experimental Group

Data on gender related difference in retention of mensuration concepts using jigsaw II co-operative learning strategy is presented in Table 4.4:

Table 4.4: Mean and Standard Deviation of Males and Females in experimental group on GRT

Group	N	$\overline{X}$	SD	Mean Difference
Males	40	23.10	5.75	
				2.14
Females	42	25.24	5.25	

Table 4.4 showed that male students exposed to Jigsaw II co-operative learning strategy obtained mean retention score of 23.10 and standard deviation of 5.75 while females taught using jigsaw II co-operative learning had mean of 25.24 with standard deviation 5.25 in GRT. Therefore, the

difference between the mean retention scores of males and females when taught mensuration using jigsaw II co-operative learning strategy is 2.14.

4.3 Data Analysis

Data obtained from GAT and GRT were subjected to statistical analyses in order to retain or reject the null hypotheses. All the four (4) hypotheses formulated in this study were tested at 0.05 level of significance using independent t-test. The results were analyzed and presented as follows:

4.3.1 Pretest Results Analysis:

GAT was administered to both experimental and control groups before the commencement of the experiment to establish the equivalence of the two groups. The result obtained was analyzed using t-test statistic at 0.05 level of significance and is presented in Table 4.5:

Table 4.5: Summary of t-test for the Performance of Experimental and Control Groups in Pretest

Group	N	$\bar{X}$	SD	df	t – cal	P	Decision
Experimental	82	12.77	4.90				
				157	1.73	0.351	**
Control	77	10.75	6.11				

** Not significant at $\propto = 0.05$

The results in table 4.5 showed that the value of t – calculated was 1.73 with P-value of 0.351. This shows P = 0.351 > 0.05. Hence, the null hypothesis is retained. This means that there is no significant difference between the experimental and control group in their pretest scores. It further implies that students of both experimental and control groups could be assumed to be equal in prior knowledge of mensuration concepts before the commencement of the study.

4.3.2 Hypotheses Testing

The four hypotheses for the study are re-stated and tested at 0.05 level of significance as follows:

HO_1: There is no significant difference between the mean performance scores of students taught mensuration concepts using jigsaw II co-operative learning strategy and those taught using conventional lecture method.

In order to test this hypothesis, post – test (GAT) mean scores of both experimental and control groups were analyzed using independent t – test statistic at 0.05 level of significance.

The summary of t – test analysis of the mean scores of experimental and control groups in posttest (GAT) is presented in Table 4.6:

Table 4.6: Summary of t-test Analysis of the Mean Performance Scores of Experimental and Control Groups in Posttest (GAT)

Group	N	$\overline{X}$	SD	df	t – cal	P	Decision

Experimental	82	28.54	5.72				
				157	11.28	0.001	*
Control	77	19.50	4.32				

*Significant at $\propto = 0.05$

Table 4.6 revealed that calculated value of t is 11.28 and the P-value 0.001. Therefore, P – value of 0.001 is less than alpha value of 0.05. Based on this evidence, the null hypothesis was rejected. This implies that there was significant difference between the mean performance scores of students taught mensuration concepts using jigsaw II co-operative learning and those taught using conventional lecture method in favour of the Jigsaw II co-operative learning group.

HO_2 : There is no significant mean difference between the retention scores of students taught mensuration using jigsaw II co-operative learning and those exposed to conventional lecture method.

To test HO_2, post -posttest (GRT) mean scores of both experimental and control groups were analyzed using independent t – test statistic at 0.05 level of significance. The summary of t – test analysis of the mean scores of experimental and control groups in post –posttest (GRT) is shown in Table 4.7:

Table 4.7: Summary of t-test Analysis of the Mean Retention Scores of Experimental and Control Groups in Post-Posttest (GRT)

Group	N	$\bar{X}$	SD	df	t – cal	P	Decision
Experimental	82	24.20	5.53				

				157	9.57	0.001	*
Control	77	16.29	4.88				

*Significant at $\propto = 0.05$

Table 4.7 showed that t – calculated is 9.57 with P-value of 0.001. Therefore, P–value of 0.001 is less than alpha value of 0.05. Therefore, the null hypothesis was rejected. This means that there was significant difference between the mean retention scores of students taught mensuration concepts using jigsaw II co-operative learning strategy and those taught using conventional lecture method in favour of the Jigsaw II co-operative learning strategy group.

HO_3: There is no significant difference in the mean performance scores of male and female students taught mensuration by jigsaw II co-operative learning strategy.

In testing HO_3, the mean performance scores of males and females in experimental group were analyzed using independent t-test at $P \leq 0.05$. Table 4.8 shows the summary of the t-test of the mean performance scores of the males and females in experimental group only.

Table 4.8: Summary of t-test Analysis of the Mean Performance Scores of Males and Females in Experimental Group in Posttest (GAT)

Group	N	$\overline{X}$	SD	df	t – cal	P	Decision

Males	40	27.55	6.07				
				80	-1.69	0.093	**
Females	42	29.57	5.14				

** Not Significant at $\propto = 0.05$

Table 4.8 revealed that the value of calculated t is -1.69 and the P – value is 0.093. This indicates that P-value of 0.093 is greater than 0.05 alpha - value. Based on this evidence, the null hypothesis was retained. This implies that there was no significant difference in the mean performance scores of males and females students in mensuration concepts when exposed to jigsaw II co-operative learning strategy.

HO_4: There is no significant difference between the mean retention scores of male and female students in mensuration aspect of geometry when exposed to jigsaw II co-operative learning strategy.

To test HO_4, the mean retention scores (GRT scores) of males and females in experimental group were analyzed using t-test at $\propto = 0.05$. Table 4.9 showed the summary of t-test of the mean retention scores of males and females in experimental group.

Table 4.9: Summary of t-test of the Mean Retention Scores of Males and Females in Experimental group in Post-Posttest

Group	N	$\bar{X}$	Sd	df	t – cal	P	Decision
Males	40	23.10	5.75				
				80	-1.88	0.063	**
Females	42	25.24	5.25				

** Not Significant at $\propto = 0.05$

Table 4.9 revealed that the value of calculated t is -1.88 and the P – value is 0.063. This indicates that P-value of 0.063 is greater than 0.05 alpha value.. Based on this evidence, the null hypothesis was retained. This implies that there was no significant difference in the mean retention ability scores of males and females students in mensuration concepts when taught by using jigsaw II co-operative learning strategy.

4.4 Summary of the Major Findings

Based on the data analyzed in this study, the following were the major findings:

1. It was found that there was significant difference between the mean performance scores of the students taught mensuration concepts using jigsaw II co-operative learning strategy and those taught using conventional lecture method. Students exposed to jigsaw II co-operative learning strategy performed significantly better than those exposed to conventional lecture method.
2. It was also found that there was significant difference between the mean retention ability scores of the students taught mensuration concepts using jigsaw II co-operative learning

strategy and those taught using conventional lecture method. Students exposed to jigsaw II co-operative learning strategy retained mensuration concepts significantly better than those exposed to conventional lecture method.

3. Although the mean performance score of females in the experimental group was higher than that of the males in the experimental group, yet, the findings revealed that the difference was not statistically significant.
4. Further, findings from the study revealed that there was no significant difference between the mean retention scores of males and females when taught using jigsaw II co-operative learning strategy.

4.5 Discussions

The study indicated the existence of significant difference between the performance of students taught using jigsaw II co-operative learning strategy and those taught using conventional lecture method in favour of those exposed to jigsaw II co-operative learning, as shown in Table 4.6. This implies that jigsaw II co-operative learning was more effective than conventional lecture method in teaching and learning mensuration aspect of geometry. This result further suggests that jigsaw II co-operative learning strategy could help to enhance students' understanding of mensuration concepts in mathematics more than the conventional lecture method. This finding agreed with the results of Gubbad (2010), Chianson, Okwu and Kurumeh (2010), Gambari, Shittu and Taiwo (2013) as well as Zakaria, Solfitri, Daud and Abidin (2013) that jigsaw II co-operative learning improved students' performance in mathematics concepts. The superiority of jigsaw II co-operative learning over the conventional lecture method can be due to the fact that it is a strategy that emphasizes specialization on one

aspect of a topic by each member of a group. Every group member must specialize on a portion of the topic while in the expert group, teach his portion to his group members, learn the whole

lesson in the home group and individually solve some tasks. Thus, each student learns and helps his group members to learn by providing opportunity for dialogue and free debate on a task, which is not obtained in the conventional lecture method. Also, the difference could be attributed to the group reward feature in-built in the jigsaw II strategy which serves as motivation to perform better in subsequent lessons by earning higher improvement scores.

The findings also revealed that there was significant difference in the retention ability of experimental group and control group (Table 4.7). Students in the experimental group significantly out-performed those in the control group in the retention test (GRT). This indicates that jigsaw II co-operative learning was superior in terms of enhancing retention of mensuration concepts more than the conventional lecture method. This finding is in line with those of Isa (2014), Chianson, Kurumeh and Obida (2010), Gubbad (2010) who found that experimental group taught using co-operative learning achieved higher in terms of retention of mathematics concepts. However, it contradicts the earlier findings of AbdulRahim and Al-Shakili (2005) and Iqbal (2004) that co-operative learning strategy and traditional lecture method produce similar effect in terms of retention of mathematical concepts. This difference in findings about retention could be attributed to the difference in location of the different studies. On the other hand, the efficacy of jigsaw II co-operative learning strategy over lecture method in enhancing retention could be linked to the fact that jigsaw II co-operative learning provides for individual differences as consideration is given to students' ability levels when forming mixed- ability groups for a learning task. In such mixed ability groups, students elaborate learning materials by teaching

their assigned portion and sharing their ideas. In the process of teaching and elaboration, students refine the learning materials and over- master the material which aid and enhance retention. This was also agreed by Azuka (2012) that provision for individual differences and over- mastering of concepts by consistent elaboration enhances retention of mathematical concepts.

The results of this study (Table 4.8) also revealed that there was no significant difference in the performance of males and females exposed to jigsaw II co-operative learning, although the mean performance score of females was higher than that of the males. The findings showed that both males and females taught by jigsaw II co-operative learning performed equally as no significant difference was found in their mean performance score. This result is in line with those of Chianson, Okwu and Kurumeh (2010), Keramati, Tahmasbi, Rafat and Khashab (2011) as well as Gambari, Shittu and Taiwo (2013) who showed that gender had no effect on academic performance of students in co-operative learning. It also supports the view point of Hassan (2010) that gender differences in geometry performance were neither as marked nor always in favor of males. The finding, however, debunked the results of Olson (2002) who found that females out-performed males when taught by co-operative learning and that of Khairulanuar, Nazre, Sairabanu and Norasikin (2010) who found gender difference in favour of males when exposed to co-operative learning.. This result indicates that jigsaw II cooperative learning favored both males and females in mensuration .aspect of geometry and the strategy is more effective in enhancing both male and female students' performance in mathematics. This suggests that when teachers use the right strategies and activities, female students would learn equally as their male counterparts. It can also be deduced that jigsaw II co-operative learning strategy bridges the gap in mathematics performance between males and females. It also

indicated that females are wonderful in mathematics when they are allowed to share ideas and interact freely among themselves.

Table 4.9 showed that there was no significant difference in the retention ability of males and females when exposed to jigsaw II co-operative learning strategy. This implies that jigsaw II co-operative learning produces similar effects on males and females in retention of mensuration concepts. This finding further implies that jigsaw II closes the gap in females' retention ability in mensuration .aspect of geometry when compared to their male counterparts. Also, the strategy is effective in improving both male and female students' retention ability in mathematics. Therefore, it would not be surprising that when females are exposed to strategies that would provide them with the opportunity to work in groups and discuss their mathematical reasoning by consistent elaboration as provided in jigsaw II co-operative learning, they would retain equally or even better than their male counterparts. It confirmed the claim of Uyuota (2006) that retention enhances performance as females also performed equally as males in this study..

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The main objectives of this study are to determine the impacts of jigsaw II co-operative learning strategy on academic performance and retention in mensuration concepts of geometry when compared to the conventional lecture method. This chapter contains the summary, conclusions as well as recommendations based on the findings of the study. It also highlights contributions of the study to knowledge. Finally, suggestions for further studies are made.

5.2 Summary of the Study

The goal of this study is to determine the impacts of jigsaw II co-operative learning strategy on academic performance and retention of mensuration concepts in geometry among senior secondary school students in Kano state, Nigeria. The independent variable in the study is

teaching method while the dependent variables are academic performance and retention. Gender is an intervening variable in the study.

Literature was reviewed which provided an account of theoretical framework for the study which is based on constructivist theory. The review ended with a critique of related studies on co-operative learning in order to highlight the direction of research on co-operative learning strategies in mathematics and other subject areas.

The target population for the study were all SSS 1 students in Kano state from 499 secondary schools. Two (2) educational zones were randomly selected from fourteen zones. Four schools (two girls' schools and two boys' schools) were then randomly selected from the two educational zones. From each of the four schools, one intact class was selected. Simple random sampling was employed to assign one girls' school and one boys' school to experimental group

while one boys' school and one girls' sch gned to control group. Thus, the sample size was 159 (82 in the experimental group and 77 in the control group)

The design of the study was quasi –experimental pre-test-post-test non - randomized. Pre-test was taken by both experimental and control groups to establish the equivalence of the groups before the commencement of the experiment. Thereafter, the experimental group was taught mensuration concepts of geometry using jigsaw II co-operative learning strategy while control group was taught by conventional lecture method for six weeks. GAT was then administered to both groups to determine the impacts of the type of treatment given to the groups on academic performance. Two weeks after GAT was taken, GRT was administered on both groups in order to determine the impacts of the type of instruction received on retention ability. Data obtained

from these instruments were analyzed using independent t-test at 0.05 level of significance. Findings revealed that:

1. There was significant difference between the mean performance scores of the students taught mensuration concepts using jigsaw II co-operative learning strategy and those taught using conventional lecture method in favor of jigsaw II co-operative learning group.
2. Students taught by jigsaw II co-operative learning strategy retained mensuration concepts significantly better than those taught by conventional lecture method.
3. There was no significant difference between the mean performance scores of males and females when taught mensuration using jigsaw II co-operative learning strategy.
4. There was no significant difference between the mean retention scores of males and females when taught using jigsaw II co-operative learning strategy.

5.3 Conclusion

The following conclusions were drawn from the findings of this study:

1. The results obtained from GAT favored students taught by jigsaw II co-operative learning more than those taught by lecture method. Therefore, it was concluded that jigsaw II co-operative learning strategy could effectively enhance and improve students' academic

performance in mensuration aspect of geometry more than the conventional lecture method.

2. Jigsaw II co-operative learning strategy proved to be more effective in improving retention of learnt mensuration concepts more than the conventional lecture method. This is based on the finding that experimental group obtained significantly higher retention scores than the control group.
3. Jigsaw II co-operative learning strategy could be employed to raise the academic performance of females in geometry concepts so as to bridge the gap in mathematics performance between boys and girls. This is based on the finding that gender is not a factor in learning mensuration concepts when jigsaw II co-operative learning is applied.
4. Jigsaw II co-operative learning strategy improves the retention ability of both males and female as gender is not a factor in retaining mensuration concepts when jigsaw II co-operative learning is employed.

5.4 Contributions to Knowledge

The study contributed to knowledge by developing two instruments, GAT and GRT, that were reliable and could be used to measure senior secondary one (SS1) students' performance and retention ability respectively in mensuration concepts of geometry.

Also, the study has provided mathematics teachers with a teaching package that can be adopted or adapted to teach mathematics especially mensuration concepts using jigsaw II co-operative learning strategy, as one of its contributions to knowledge.

Other studies cited in this work were mostly on other co-operative learning strategies such as jigsaw and Students' Teams Achievement Division (STAD). These cited studies were

conducted in locations different from the study area of this work. However, this study was able to establish, empirically, that jigsaw II co-operative learning strategy could be effectively used to enhance students' performance and retention in mensuration in Kano State senior secondary schools, where performance in the subject has been very low. This, in turn, could lead to a positive change in the students' performance and their perception of geometry as a difficult area.

Furthermore, the gap between males and females in mathematics performance and retention has remained a source of concern among mathematics educators. This gap has gone to the extent that females regard mathematics as an exclusive area for males only. This study has proved that with the use of jigsaw II co-operative learning strategy in mathematics teaching, females can perform and retain equally, as well, as their males counterparts. Hence, the notion that mathematics is for males only, will be changed positively when mathematics teachers use jigsaw II co-operative learning strategy to teach mathematics.

Finally, literature search showed that mensuration aspect of geometry has been neglected by mathematics education researchers on co-operative learning. To the best knowledge of this researcher, no research was conducted on the efficacy of jigsaw II co-operative learning to determine its impacts on performance and retention in mensuration concepts. Also, no research was conducted on the impact of jigsaw II co-operative learning strategy on retention of learnt

mensuration concepts by gender. Therefore, the present study has added new knowledge to the existing literature as one of its contribution to the existing body of knowledge.

5.5 Recommendations

In order to improve academic performance and retention of mensuration concepts among senior secondary school students, the following measures are recommended:

1. Mathematics teachers should be trained on effective procedures for implementing jigsaw II co-operative learning in their classrooms by organizing extensive seminars and workshops. This will assist in improving students' performance in mathematics.
2. Mathematics educators, professional associations in mathematics as well as mathematics textbook developers should incorporate jigsaw II co-operative learning procedures in their future publications for enhanced students' academic performance and retention of mathematics concepts.
3. Mathematics teachers at secondary school level should use jigsaw II co-operative learning strategy in their lesson delivery for improved performance and retention of learning. This will help to close the existing gap in mathematics performance and retention between boys and girls and could even make the girls better achievers in mathematics.
4. Teacher-training institutions should include jigsaw II co-operative learning strategy in their mathematics methodology course content. This will greatly assist in ensuring that prospective secondary school mathematics teachers are adequately trained on how to use the strategy in their classrooms for improved students' performance.

5.6 Suggestions for Further Studies

It is suggested that further studies should be conducted in the following areas:

1. Studies in which jigsaw II co-operative learning strategy will be used for a longer duration (a whole term in secondary schools or a whole semester in tertiary institutions) should be conducted to determine whether students' performance and retention is increased with additional experience in using the strategy.
2. Further studies should focus on comparison between jigsaw II co-operative learning and other co-operative learning strategies in order to determine whether other co-operative learning strategies can equally enhance students' performance and retention in mathematics.
3. Similar studies should be carried out using larger samples than the sample size used in this study.
4. Similar study should be carried out at secondary schools owned by federal government and even private schools.
5. Further studies should be conducted in other branches of mathematics like algebra, trigonometry, statistics and other topics in further mathematics that are included in the new senior secondary school mathematics curriculum.
6. Similar study should be carried out using senior secondary schools that operate co-educational system in other states, to find out what the results will be in relation to gender performance difference when jigsaw II co-operative learning is employed.

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APPENDIX A

GEOMETRY ACHIEVEMENT TEST (GAT)

NAME OF SCHOOL: ----------

SEX : ---------- CLASS:---------- TIME: 1HR 15MINS

Instruction: Answer ALL the questions by circling the correct option from the given options lettered A – D. Take $\pi = \frac{22}{7}$ where applicable.

1. A cube has a length of 6cm. Find its surface area.

a. $226cm^2$ b. $72cm^2$ c. $202cm^2$ d. $216cm^2$

2. A closed matchbox has dimensions 5.5cm by 3.5cm by 1.5cm. Find, correct to the nearest whole number, the surface area of the box.

a. $66cm^2$ b. $33cm^2$ c. $29cm^2$ d. $21cm^2$

3. A rectangular tank is in the form of a cuboid with base 1.2m by 1.5m. There are 2700 litres of water in the tank. What is the depth of the water in the tank?

a. 15.0 m b. 2.7m c. 1.5m d. 1.8m

4. A rectangular tank is 76cm long, 50cm wide and 40cm high. How many litres of petrol can it hold?

a. 15200 litres b. 1520 litres c. 152 litres d. 1420 litres

5. The surface areas of two cubes are in the ratio 54: 294. What is the ratio of their lengths?

a. 4:7 b. 7:4 c. 3:7 d. 9:7

6. A cube has a surface area of $54cm^2$. Find its volume.

a. $3cm^3$ b. $27cm^3$ c. $9cm^3$ d. $18cm^3$

7. The volumes of two cubes are in the ratio 27: 125. What is the ratio of their lengths?

a. 3:5 b. 9:25 c. 2:5 d. 9: 3

8. A cylindrical pipe is 28m long. Its internal radius is 3.5cm with external radius of 5cm. calculate the volume of water, in litres, that the pipe can hold when full.

a. 1080 litres b. 107.8 litres c. 1070 litres d. 178. 8 litres

9. A cylindrical container has a volume of $4752m^3$. If the container is 42m long, what is its diameter?

a. 12m b. 24m c. 6m d. 3m

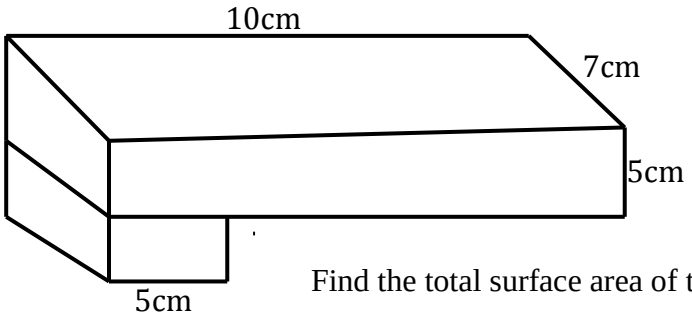
10. A closed cylindrical pipe is 20cm long with radius 10cm. Find the total surface area of the pipe to the nearest whole number.

a. $1886cm^2$ b. $1257cm^2$ c. $2885cm^2$ d. $1885cm^2$

11. How many solid cubes of length 5cm can be made from a cuboid of length 10cm, breadth 10cm and height 7.5cm?

a. 25 b. 15 c. 10 d. 6

12. A cuboid of dimension 10cm by 7cm by 5cm is combined with a cube of side 5cm to form the solid shown below:



Find the total surface area of the solid

a. $310cm^2$ b. $315cm^2$ c. $410cm^2$ d. $305cm^2$

13. Find the volume of the solid in Q12 above

a. $475cm^3$ b. $350cm^3$ c. $225cm^3$ d. $575cm^3$

14. A carpenter was told to make a box in the shape of a cube of length 1.6m. What is the surface area of wood required?

a. $19.2m^2$ b. $9.2\ m^2$ c. $13.63\ m^2$ d. $15.36\ m^2$

15. A box in the shape of a cuboid is to be covered with a cloth. Calculate the area of cloth required if the cuboid is 8m by 5m by 3m.

a. 54 m^2 b. 79 m^2 c. 164 m^2 d. 158 m^2

16. Calculate, in terms of π, the total surface area of a cylinder which is open at one end with radius 3cm and height 4cm

a. 42 π cm^2 b. 33 π cm^2 c. 24 π cm^2 d. 21 π cm^2

17. How many litres of oil does a cylindrical drum 28cm in diameter and 50cm deep holds?

a. 30800 litres b. 30.8 litres c. 308 litres d. 3.80 litres

18. How many covered square boxes of edge 8cm can be made from a wooden board of area 2688cm^2?

a. 7 boxes b. 8 boxes c. 21 boxes d. 15 boxes

19. The height of a closed cylinder h is equal to its radius r. Express the total surface area of the cylinder in terms of π and r.

a. π r^2 b. 6 π r^2 c. 4 π r^2 d. 2 π r^2

20. A closed rectangular tank 180cm by 300cm by 200cm is made of metal sheet. How many square metal sheets of area 10m^2 will be required to make the tank?

a. 35 sheets b. 3 sheets c. 300 sheets d. 60 sheets

21. An open rectangular box has internal dimensions 2m long, 20cm wide and 22.5 cm deep. If the box is made up of wood 2.5cm thick, calculate the volume of the wood in cm^3.

a. 3825cm^3 b. 38125cm^3 c. 38200cm^3 d. 32805cm^3

22. A rectangular tank 60cm by 80cm by 100cm is half - filled with water. How many litres of water is it holding?

a. 240 litres b. 480 litres c. 1200 litres d. 2400 litres

23. Calculate the volume of the material used in making a pipe 20cm long with an internal diameter of 6cm and external diameter 8cm.

a. $200cm^3$ b. $440cm^3$ c. $540cm^3$ d. $330cm^3$

24. A cylindrical jar of radius 35cm contains water 20cm high. The water is poured into a tank in form of cuboid whose base is 42cm by 30cm. find, correct to 2 significant figures, the height of the water level in the tank..

a. 21cm b. 61cm c. 56cm d. 66cm

25. A cylindrical well of radius 1m is dug out to a depth of 8m. If the soil dug out is used to raise the level of a rectangular floor of a room 4m by 12m, calculate, to the nearest cm, the thickness of the new layer of the soil.

a. 25cm b. 56cm c. 62cm d. 52cm

26. The volume of a cylinder is $216cm^3$. A similar cylinder has a volume of $125cm^3$. If the height of the larger cylinder is 30cm, find the height of the smaller cylinder.

a. 20cm b. 18cm c. 25cm d. 10cm

27. Two similar boxes in the shape of a cube have volumes of $250cm^3$ and $54cm^3$. What is the ratio of their surface areas?

a. 125:3 b. 25:9 c. 5: 9 d. 150 : 54

28. A circular metal sheet 24cm in radius and 2mm thick is melted and recast into a cylindrical bar radius 3cm. find the height of the bar.

a. 12.8 cm b. 25.6cm c. 13cm d. 20.6cm

29. The base area of a rectangular water tank is $1.2m^2$. The tank is 1.35m deep and is half - full of water. How many times can a 9-litres bucket be filled from the tank?

a. 100 times b. 148 times c. 90 times d. 98 times

30. A solid cube of side 8cm is dropped into a cylindrical tank of diameter 14cm. calculate, to the nearest whole number, the rise in the water level if the original depth of water was 9cm.

a. 9cm b. 12cm c. 6cm d. 3cm

APPENDIX B

SOLUTIONS TO GEOMETRY ACHIEVEMENT TEST (GAT)

1.	D	11.	D	21	B
2.	A	12.	C	22	A
3	C	13.	A	23	B
4	C	14.	D	24	B
5	C	15.	D	25	D
6	B	16.	B	26	C
7	A	17.	B	27	B
8.	B	18.	A	28	A
9.	A	19.	C	29	C
10.	A	20.	B	30.	D

APPENDIX C

GEOMETRY RETENTION TEST (GRT)

NAME OF SCHOOL: ----------

SEX : ---------- CLASS:---------- TIME: 1HR 15MINS

Instruction: Answer ALL the questions by circling the correct option from the given options lettered A – D. Take $\pi = \frac{22}{7}$ where applicable.

1. A rectangular tank is 76cm long, 50cm wide and 40cm high. How many litres of petrol can it hold?

a. 152 litres b. 1420 litres c. 15200 litres d. 1520 litres

2. A cube has a surface area of 54cm^2. Find its volume.

a. 18cm^3 b. 27cm^3 c. 9cm^3 d. 3cm^3

3. A cube has a length of 6cm. Find its surface area.

a. 202cm^2 b. 216cm^2 c. 226cm^2 d. 72cm^2

4. The volumes of two cubes are in the ratio 27: 125. What is the ratio of their lengths?

a. 3:5 b. 9:3 c. 2:5 d. 9: 25

5. A closed cylindrical pipe is 20cm long with radius 10cm. find the total surface area of the pipe to the nearest whole number.

   a. 1885cm^2 b. 2885cm^2 c. 1257cm^2 d. 1886cm^2

6. A closed matchbox has dimensions 5.5cm by 3.5cm by 1.5cm. Find, correct to the nearest whole number, the surface area of the box.

a. $33cm^2$ b. $21cm^2$ c. $66cm^2$ d. $29cm^2$

7. The surface areas of two cubes are in the ratio 54: 294. What is the ratio of their lengths?

a. 7:4 b. 9:7 c. 4:7 d. 3:7

8. A tank is in the form of a cuboid with base 1.2m by 1.5m. There are 2700 litres of water in the tank. What is the depth of the water in the tank?

a. 2.7 m b. 15.0m c. 1.8m d. 1.5m

9. How many solid cubes of length 5cm can be made from a cuboid of length 10cm, breadth 10cm and height 7.5cm?

a. 15 b. 25 c. 6 d. 10

10. A cylindrical pipe is 28m long. Its internal radius is 3.5cm with external radius of 5cm. calculate the volume of water, in litres, that the pipe can hold when full.

a. 178.8 litres b. 1070 litres c. 107.8 litres d. 1080 litres

11. A rectangular tank 60cm by 80cm by 100cm is half filled with water. How many litres of water is it holding?

a. 480 litres b. 240 litres c. 2400 litres d. 1200 litres

12. A cylindrical container has a volume of $4752m^3$. If the container is 42m long, what is its diameter?

a. 24m b. 12m c. 3m d. 6m

13. Calculate the volume of the material used in making a pipe 20cm long with an internal diameter of 6cm and external diameter 8cm.

a. $540cm^3$ b. $330cm^3$ c. $440cm^3$ d. $200cm^3$

14. The volume of a cylinder is 216cm^3. A similar cylinder has a volume of 125cm^3. If the height of the larger cylinder is 30cm, find the height of the smaller cylinder.

a. 25cm b. 10cm c. 20cm d. 18cm

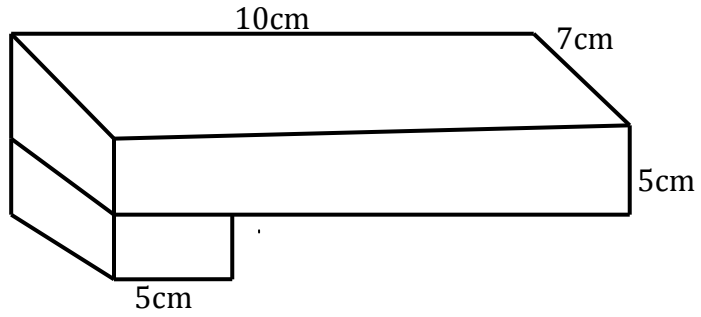
15. An open rectangular box has internal dimensions 2m long, 20cm wide and 22.5 cm deep. If the box is made up of wood 2.5cm thick, calculate the volume of the wood in cm^3.

a. 32805cm^3 b. 38200cm^3 c. 38125cm^3 d. 3825cm^3

16. Two similar boxes in the shape of a cube have volumes of 250cm^3 and 54cm^3. What is the ratio of their surface areas?

a. 125:3 b. 5:9 c. 5: 3 d. 150 : 54

17. A cuboid of dimension 10cm by 7cm by 5cm is combined with a cube of side 5cm to form the solid shown below:



Find the total surface area of the solid

a. 410cm^2 b. 310cm^2 c. 305cm^2 d. 315cm^2

18. Find the volume of the solid in Q12 above

a. 475cm^3 b. 350cm^3 c. 575cm^3 d. 225cm^3

19. A cylindrical jar of radius 35cm contains water 20cm high. The water is poured into a tank in form of cuboid whose base is 42cm by 30cm. find, correct to 2 significant figures, the height of the water level in the tank..

a. 61cm b. 21cm c. 66cm d. 56cm

20. A cylindrical well of radius 1m is dug out to a depth of 8m. If the soil dug out is used to raise the level of a rectangular floor of a room 4m by 12m, calculate, to the nearest cm, the thickness of the new layer of the soil.

a. 56cm b. 25cm c. 52cm d. 62cm

21. A carpenter was told to make a box in the shape of a cube of length 1.6m. What is the surface area of wood required?

a. $19.2m^2$ b. $9.2\ m^2$ c. $13.63\ m^2$ d. $15.36\ m^2$

22. A box in the shape of a cuboid is to be covered with a cloth. Calculate the area of cloth required if the cuboid is 8m by 5m by 3m.

a. $54\ m^2$ b. $79\ m^2$ c. $164\ m^2$ d. $158\ m^2$

23. Calculate, in terms of π, the total surface area of a cylinder which is open at one end with radius 3cm and height 4cm

a. $42\ \pi\ cm^2$ b. $33\ \pi\ cm^2$ c. $24\ \pi\ cm^2$ d. $21\ \pi\ cm^2$

24. How many litres of oil does a cylindrical drum 28cm in diameter and 50cm deep holds?

a. 30800 litres b. 30.8 litres c. 308 litres d. 3.80 litres

25. How many covered square boxes of length 8cm can be made from a wooden board of area $2688cm^2$?

a. 7 boxes b. 8 boxes c. 21 boxes d. 15 boxes

26. A circular metal sheet 24cm in radius and 2mm thick is melted and recast into a cylindrical bar radius 3cm. find the length of the bar.

    a. 12.8 cm b. 25.6cm c. 13cm d. 20.6cm

27. The base area of a rectangular water tank is $1.2m^2$. The tank is 1.35m deep and is half - full of water. How many times can a 9-litres bucket be filled from the tank?

    a. 100 times b. 148 times c. 90 times d. 98 times

28. A solid cube of side 8cm is dropped into a cylindrical tank of diameter 14cm. calculate, to the nearest whole number, the rise in the water level if the original depth of water was 9cm.

    a. 9cm b. 12cm c. 6cm d. 3cm

29. The height of a closed cylinder h is equal to its radius r. Express the total surface area of the cylinder in terms of π and r.

    a. πr^2 b. $6 \pi r^2$ c. $4 \pi r^2$ d. $2 \pi r^2$

30. A closed rectangular tank 180cm by 300cm by 200cm is made of metal sheet. How many square metal sheets of area $10m^2$ will be required to make the tank?

    a. 35 sheets b. 3 sheets c. 300 sheets d. 60 sheets

APPENDIX D

SOLUTIONS TO GEOMETRY RETENTION TEST (GRT)

1.	A	11.	A	21.	D
2.	B	12.	B	22	D
3.	B	13.	C	23	B
4.	A	14.	A	24	B
5.	D	15.	C	25	A
6.	C	16.	D	26	A
7.	D	17.	A	27	C

8.	D	18.	A	28	D
9.	C	19.	A	29	C
10.	C	20.	C	30	B

APPENDIX E

LESSON PLANS FOR CONTROL GROUP

WEEK 1 (LESSON 1)

Class: SS1

Subject: Mathematics

Topic: Surface area of a cube

Duration: 80 mins

Instructional materials: Objects that are cubes in shape both real ones and their models.

Behavioral Objectives: At the end of the lesson, students should be able to:

- Calculate the surface area of a cube
- Calculate the length of a cube given the surface area
- Compare the surface areas of two cubes
- Apply surface area to practical problems

Previous Knowledge: Students can identify cubes and state the number of faces as well as the area of each face in a cube.

Introduction: The teacher asks the students to:

- Identify the faces of the cubes supplied to them
- State the number of faces, their shapes and area of each face

He explains what surface area of a cube means

Presentation:

Step 1: Using students' responses in the introduction, the teacher derives the formula for surface area of a cube. Thus:

- A cube has 6 faces
- Each face is square in shape whose area is L^2

- Total surface area is 6 x L^2 = 6 L^2

Students listen and watch the teacher

Step 2: The teacher solves the following examples while students listen and watch the teacher:

Examples

1: Calculate the surface area of a cube whose length is 7cm.

2: The surface area of a cube is 1350cm^2. Calculate the height of the cube.

3: The heights of two cubes are in the ratio 3:7. What is the ratio of their surface areas?

4: A tank is in form of a cube length 7m. How much will it cost to cover the tank with a cloth if a m^2 of the cloth costs #220.

Step 3: The teacher allows the students to ask questions on the solved examples,

Evaluation: The teacher calls some students to solve the following problems on the board:

1. Find the surface area of a cube length 11cm
2. If the surface area of a cube is 216cm^2, find the height of the cube

3. The surface areas of two cubes are in the ratio 54: 254. What is the ratio of their lengths?

Conclusion: The teacher asks the students to copy the solved examples into their notebooks. He goes round to mark notes copied.

WEEK 2 (LESSON 2)

Class: SS1

Subject: Mathematics

Topic: Surface area of a cuboid

Duration: 80 mins

Instructional materials: Objects that are cubes and cuboids in shape both real ones and their models.

Behavioral Objectives: At the end of the lesson, students should be able to:

- Calculate the surface area of a cuboid
- Calculate the unknown side of a cuboid (length, breadth or height) given the surface area
- Solve problems on change of shape involving surface area of cuboid

Previous Knowledge: Students can differentiate between cubes and cuboids. They can state the number of faces as well as the area of each face in a cuboid. They can also find the surface area of a cube.

Introduction: The teacher asks the students to:

- State the similarities and differences between a cube and a cuboid

- State the area of each face of a cuboid.

The teacher then explains the concept of surface area of cuboid

Presentation:

Step 1: The teacher derives the formula for finding the surface area of a cuboid as follows:

- A cuboid has 6 faces
- Each face is a rectangle with areas as follows:1 pair = lb, another pair = lh, the other pair = bh
    - Total surface area = 2lb + 2lh + 2bh

      = 2(lb + lh + bh)

Students listen and watch the teacher

Step 2: The teacher solves the following examples while the students listen and watch:

1: Calculate the total surface area of a cuboid of length 25cm, breadth 20cm and height 15cm.

2: A closed matchbox has a surface area of 340cm^2. If the base of the box is 10cm by 8cm, find the height of the box.

3: A wooden cuboid is 3.2m long and 2m high. If its surface area is 28.4 cm^2, find the width of the cuboid.

4: A cuboid is 10cm by 8cm by 7cm. if the cuboid is re-casted into a cube with equal surface area as the cuboid. Find the length of the cube

Step 3: Students are allowed to ask questions jot down worked examples in their notebooks.

Evaluation: Some students are called upon to solve the following problems on the board:

1. Calculate the total surface area of a cupboard which measures120cm by 65cm by 80cm
2. The surface area of a closed matchbox is 28.4cm^2. if the base of the box measures 3.2cm by 1.5cm, what is the height of the box?
3. If a cuboid of dimension 10cm by 10cm by 7.5cm is re-casted into a cube of the same surface area, calculate the height of the cube, to the nearest whole number and find its volume.

Conclusion: The teacher comments on the solutions to the evaluation questions above. He asks the students to copy the solutions and goes round to mark students' notes.

WEEK 3 (LESSON 3)

Class: SS1

Subject: Mathematics

Topic: Surface area of a cylinder

Duration: 80 mins

Instructional materials: Objects that are cylindrical in shape, both real ones and their models.

Behavioral Objectives: At the end of the lesson, students should be able to:

- Calculate the curved surface area and total surface area of a cylinder
- Calculate the unknown radius or height of a cylinder given the surface area
- Compare surface areas of two cylinders

Previous knowledge: Students can identify the surfaces of a cylinder and can state the area of the Circular surfaces.

Introduction: The teacher asks the students to identify the surfaces of the cylinders supplied to them and state the area of each surface. He explains the concept of surface area as it relates to cylinder.

Presentation:

Step 1: From the students' responses in the introduction, the teacher explains the formulae for surface area of a cylinder. Thus:

Curved surface area = $2\pi rh$

Total surface area = area of circular faces + curved surface area

$= 2\pi r r^2 + 2\pi rh$

$= 2\pi r (r + h)$

Step 2: The teacher works out the following examples while students listen and watch:

Examples:

1: Calculate the total surface area of a cylindrical tin whose diameter is 21cm and height 12cm.

2: A solid cylinder with base radius 3.5cm has a total surface area of $341cm^2$. Calculate its height.

3: A cylinder height 10cm is 28cm in diameter. What is the difference between its curved surface area and its total surface area?

4: The heights of two cylindrical drums are in the ratio 7:8 and their base radii are in the ratio 4:3. What is the ratio of their curved surface area?

Step 3: Students are allowed to ask questions and copy the worked examples in their notebooks.

Evaluation: Some students are called upon to solve the following problems on the board:

1. A closed cylindrical pipe is 20cm long with radius 10cm. find the total surface area of the cylinder.
2. A solid cylinder with height 12cm has a total surface area of $341cm^2$. Find its diameter.
3. The diameters of two cylindrical pipes are in the ratio 6:5 while their heights are in the ratio 7:10. What is the ratio of their curved surface areas.

Conclusion: The teacher comments on the solutions, give corrections and allow students to copy the solutions in their exercise books.

WEEK 4 (LESSON 4)

Class: SS1

Subject: Mathematics

Topic: Volume of a cube

Duration: 80 minutes

Instructional materials: Objects that are cubes in shape both real ones and their models.

Behavioral Objectives: At the end of the lesson, students should be able to:

- Calculate the volume of a cube
- Find the length of a cube given the volume
- Compare volumes of two cubes

Previous knowledge: Students can order cubes by their sizes and by amount of space inside them. They can also build larger cubes from small ones.

Introduction: The teacher asks the students to order the cubes supplied to them based on the amount of space inside each. He also asks them to use the small cubes to build a large cube and use the large cube to explain what is meant by volume of a cube.

Presentation:

Step 1: Using the larger cubes constructed by students, the teacher derives the formula for volume of a cube. Thus:

- For large cube with 8 cubes, length = 2 cubes and volume = 8 cubes
- But in a cube, length (l) = breadth (b) = height (h)
- So, l = b= h = 2 cubes
- But 2 x 2 x 2 = 8 ——— l x l x l = 8 cubes

  Volume of a cube = l x l x l = l^3

Step 2: The teacher solves the following examples while students listen and watch the teacher:

Examples:

1: Calculate the volume of a cube of height 2.5m.

2: If the volume of a cube is 2197m^3, find its length.

3 : The volumes of two cubes are in the ratio 216: 1331. What is the difference between the lengths of the two cubes?

4: A tank 150cm high is in form of a cube. If it is half – filled with petrol, how many litres of petrol is it holding?

Step 3: The teacher allows students to ask questions on the solved examples. They are also asked to copy the examples into their notebooks.

Evaluation: The teacher gives class work and goes round to assist students with difficulties

Class work:

1. A cube is 4cm long. Calculate its volume.
2. The volume of a cube is 1331cm^3. Find the base area of the cube

3. The volumes of two cubes are in the ratio 27: 125. What is the ratio of their heights?

Conclusion: The teacher goes round to mark the class work. He also gives corrections for the students to copy.

WEEK 5 (LESSON 5)

Class: SS1

Subject: Mathematics

Topic: Volume of a cuboid

Duration: 80 mins

Instructional materials: Objects that are cubes and cuboids in shape both real ones and their models.

Behavioral Objectives: At the end of the lesson, students should be able to:

- Calculate the volume of a cuboid
- Calculate the unknown side of a cuboid (length, breadth or height) given the volume
- Find the volume of similar cuboids
- Solve problems on addition and subtraction of volumes of cuboid

Previous knowledge: Students can build larger cuboids using small cubes. They can also find volume of cubes.

Introduction: The teacher asks the students to build large cuboid using the small cubes supplied to them. He used the large cuboids to explain what is meant by volume of cuboid.

Presentation:

Step 1: Using the large cuboids constructed by the students, the teacher derives the formula for finding the volume of a cuboid. Thus:

- If a cuboid is made of length (l) = 2 cubes, breadth = 3 cubes and height = 4 cubes, then it is made of 24 cubes.
- But l =2, b =3 and h= 4 l x b x h = 24 cubes
- Volume of cuboid = l x b x h = base area x height

Step 2: The teacher solves examples on the board while the students listen and watch.

Examples:

1: A rectangular tank is 86cm by 60cm by 50cm. How many litres of petrol can it hold?

2: The volume of a cuboid is $0.48m^3$. If its dimension is 1.5m by 0.5m by x, What is the value of x?

3: Two similar rectangular boxes have volumes of $250cm^3$ and $54cm^3$. What is the ratio of their heights?

4: An open rectangular box measures externally 32cm long, 27cm wide and 15cm deep. If the box is made of wood 1cm thick, what volume of wood is used to make the box?

Step 3: Students are allowed to ask questions and copy the worked examples in their notebooks.

Evaluation: The teacher gives class work and goes round to assist students with difficulties

Class work:

1. Find the volume of a cuboid 1.8m long, 2.4m wide and 2.5m high.
2. A cuboid holds 1 litre of water. If its base is 12.5cm by 20cm, calculate the height of the cuboid.

3. An open rectangular box made of wood 1.5 cm thick is measures externally 63cm by 48cm by 50cm. Calculate: (a) the volume of wood in the box (b) the mass of the box if the density of the wood is $0.8g/cm^3$.

Conclusion: The teacher goes round to mark the class work. He also gives corrections for the students to copy.

WEEK 6 (LESSON 6)

Class: SS1

Subject: Mathematics

Topic: Volume of cylinder

Duration: 80 mins

Instructional materials: Objects that are cubes cylindrical in shape, both real ones and their models.

Behavioral Objectives: At the end of the lesson, students should be able to:

- Calculate the volume of a cylinder
- Determine the height or radius of a cylinder given the volume
- Solve problems on addition and subtraction of volumes involving cylindrical shapes
- Find volume of similar cylindrical shapes

Previous knowledge: Students can define volume of a cuboid as base area x height. They can state the base area of cylinders.

Introduction: The teachers asks the students to name the shape of the base of the cylinders supplied to them and the base area. They are also asked to identify the height of the cylinders. The teacher then explains the concept of volume of cylinder.

Presentation:

Step 1: The teacher derives the formula for volume of cylinder. Thus:

- Base area = πr^2 and height = h
- Volume = base area x height

  $= \pi r^2 \text{ x } h = \pi r^2 h$

Step 2: The teacher gives examples on volume of cylinder as students listen and watch.

Examples:

1: A cylindrical well of radius 1m is dug out to a depth of 8m. Calculate, in m^3, the volume of soil dug out.

2: 154 litres of oil is poured into a cylindrical barrel of diameter 35cm. To what depth is the drum filled?

3: A cylindrical pipe is 28m long. Its internal diameter is 7cm with external diameter of 10cm. Calculate the volume of material, in cm^3, used in making the pipe.

4: If an oil drum with capacity of 25 litres is 60cm deep, find the depth of a similar drum which holds 1.6 litres

Step 3: Students ask questions and copy the solved examples into their books.

Evaluation: The teacher gives class work and goes round to assist students with difficulties.

Class work:

1. A cylindrical funnel has a base diameter 12cm and a vertical height 30m. calculate its volume.
2. A cylindrical pipe is 28cm long. Its internal radius is 3.5cm with external radius of 5cm. Calculate the volume of material used in making the pipe.
3. The volume of a cylinder is $216cm^3$. A similar cylinder has a volume of $125cm^3$. If the height of the smaller cylinder is 25cm, how long is the larger cylinder?

Conclusion: The teacher goes round to mark the class work. He also gives corrections for the students to copy.

APPENDIX F

JIGSAW II CO-OPERATIVE TEACHING STRATEGY GUIDE

(FOR TEACHING EXPERIMENTAL GROUP)

WEEK 1 (LESSON 1: SURFACE AREA OF A CUBE)

PRELIMINARY INFORMATION

Subject: Mathematics

Class: SS1

Time: 80 minutes

Content: Surface area of a cube

Materials: Objects that are cubes and cuboids in shape, both real and models. MAN Mathematics for Senior Secondary Schools for SS 1 – Chapter 17 on surface area and volumes of cube, cuboid and cylinder, expert sheets containing 4 questions on 4 sub-topics of surface area of a cube

BEHAVIOURAL OBJECTIVES: At the end of the lesson, students will be able to:

- calculate the surface area of a cube
- calculate the length of a cube given the surface area
- compare the surface area of cubes
- apply surface area of a cube to practical problem

CHOOSING GROUPS: The teacher forms heterogeneous groups using the pre-test results of the students. Each group will contain 4 students with high, medium and low ability level students. These original groups are called jigsaw or home groups.

PRESENTING THE CONTENT:

- Teacher distributes lesson materials to students and assigns group roles to students using numbed heads (Each student is assigned a number from 1 to 4. 1's is for team leader, 2's for recorder, 3's for checker and 4's for timekeeper)..
- Task assignment: Teacher assigns one task/question from the expert sheet on different sub-topics of surface area of a cube using numbered heads to each of the 4 members of the original jigsaw group
- Students review co-operative learning roles responsibilities and ground rules for group work written and pasted on the board while the teacher explains the jigsaw II co-operative learning procedures.

READING: Each member focus on reading the sub-topic assigned to him or her for some time using the material supplied.

EXPERT GROUP DISCUSSION: Each member in the home group meets other members assigned the same task to form expert group. In the expert group, they study the assigned question/task on the expert sheet together, discuss and share information on their topic until they complete the task and get the answer. They take notes to help them in teaching home group members

HOME GROUP REPORTING: Students return to their original jigsaw groups to teach the remaining members what they have learnt in the expert group on their topic. Each member listens, contribute, ask questions and take notes on what each expert discusses.

As the group work progresses, the teacher goes round the groups to give assistance, encourage and praise collaborative skills and learn more about the students.

WHOLE CLASS DISCUSSION: The teacher allows a brief whole class discussion to clear doubts, if any, as well as provoke further discussion on the topic. **EVALUATION:** Students are given the following short quiz to test their knowledge on the learnt material:

1. Find the surface area of a cube length 11cm
2. If the surface area of a cube is 216cm^2, find the height of the cube
3. The surface areas of two cubes are in the ratio 54: 254. What is the ratio of their lengths?

GROUP RECOGNITION: Students exchange their scripts. The teacher provides marking guide on the board and students mark the scripts. Being the first lesson, the class average is used as base score and individual improvement score calculated by the students, from which each group's average improvement score is obtained. The group with the highest average improvement score receives a group reward.

CLOSURE: Students clap for themselves for the day's work and teacher assigns each group member a task/question on the expert sheet for next lesson so that students read as home work to save the next lesson time.

WEEK 2 (LESOON 2: SURFACE AREA OF A CUBOID)

PRELIMINARY INFORMATION

Subject: Mathematics

Class: SS1

Time: 80 minutes

Content: Surface area of a cuboid

Materials: Objects that are cubes and cuboids in shape, both real and models. MAN Mathematics for Senior Secondary Schools for SS 1 – Chapter 17 on surface area and volumes of cube, cuboid and cylinder, expert sheets containing 4 questions on 4 sub-topics of surface area of a cuboid

BEHAVIOURAL OBJECTIVES: At the end of the lesson, students will be able to:

- calculate the surface area of a cuboid
- find the unknown side of a cuboid given the surface area and 2 other sides
- solve problems on change of shape involving surface area of cuboid

CHOOSING GROUPS: The teacher uses previous heterogeneous groupings with necessary adjustments based on his observations in last lesson. Each group will contain 4 students with high, medium and low ability level students. These original groups are called jigsaw or home groups.

PRESENTING THE CONTENT:

- Teacher distributes lesson materials to students and assigns group roles to students using numbed heads (Each student is assigned a number from 1 to 4. 1's is for team leader, 2's for recorder, 3's for checker and 4's for timekeeper).
- Task assignment: Teacher assigns one task/question from the expert sheet on different sub-topics of surface area of a cuboid using numbered heads to each of the 4 members of the original jigsaw group
- Students review co-operative learning roles responsibilities and ground rules for group work written and pasted on the board while the teacher explains the jigsaw II co-operative learning procedures..

  READING: Each member focus on reading the sub-topic assigned to him or her for some time.

EXPERT GROUP DISCUSSION: Each member in the home group meets other members assigned the same task to form expert group. In the expert group, they study the assigned question/task on the expert sheet together, discuss and share information on their topic until they complete the task and get the answer. They take notes to help them in teaching home group members

HOME GROUP REPORTING: Students return to their original jigsaw groups to teach the remaining members what they have learnt in the expert group on their topic. Each member listens, contribute, ask questions and take notes on what each expert discusses.

As the group work progresses, the teacher goes round the groups to give assistance, encourage and praise collaborative skills and learn more about the students.

WHOLE CLASS DISCUSSION: The teacher allows a brief whole class discussion to clear doubts, if any, as well as provoke further discussion on the topic.

EVALUATION: Students are given short quiz on the topics they have learnt in their jigsaw groups.

1. Calculate the total surface area of a cupboard which measures120cm by 65cm by 80cm
2. The surface area of a closed matchbox is 28.4cm^2. if the base of the box measures 3.2cm by 1.5cm, what is the height of the box?
3. If a cuboid of dimension 10cm by 10cm by 7.5cm is re-casted into a cube of the same surface area, calculate the height of the cube, to the nearest whole number and find its volume.

GROUP RECOGNITION: Students exchange their scripts. The teacher provides marking guide on the board and students mark the scripts. The 1st lesson quiz score is used as base score and individual improvement score calculated by the students, from which each group's average improvement score is obtained. The group with the highest average improvement score receives a group reward.

CLOSURE: Students clap for themselves for the day's work and teacher assigns each group member a task/question on the expert sheet for next lesson so that students read as home work to save time for the next lesson.

WEEK 3 (UNIT 3: SURFACE AREA OF A CYLINDER)

PRELIMINARY INFORMATION

Subject: Mathematics

Class: SS1

Time: 80 minutes

Content: Surface area of a cylinder

Materials: Objects that are cylindrical in shape, both real and models. MAN Mathematics for Senior Secondary Schools for SS 1 – Chapter 17 on surface area and volumes of cube, cuboid and cylinder, expert sheets containing 4 questions on 4 sub-topics of surface area of a cylinder

BEHAVIOURAL OBJECTIVES: At the end of the lesson, students will be able to:

- Calculate the curved and total surface area of a cylinder
- Find the unknown value (radius or height) given the surface area and the other value
- Compare the surface areas of cylinders

CHOOSING GROUPS: The teacher uses previous heterogeneous groupings with necessary adjustments based on his observations in last lesson. Each group will contain 4 students with high, medium and low ability level students. These original groups are called jigsaw or home groups.

PRESENTING THE CONTENT:

- Teacher distributes lesson materials to students and assigns group roles to students using numbed heads (Each student is assigned a number from 1 to 4. 1's is for team leader, 2's for recorder, 3's for checker and 4's for timekeeper).

- Task assignment: Teacher assigns one task/question from the expert sheet on different sub-topics of surface area of a cylinder using numbered heads to each of the 4 members of the original jigsaw group.

- Students review co-operative learning roles responsibilities and ground rules for group work written and pasted on the board while the teacher explains the jigsaw II co-operative learning procedures.

READING: Each member focus on reading the sub-topic of the learning material assigned to him or her for some time.

EXPERT GROUP DISCUSSION: Each member in the home group meets other members assigned the same task to form expert group. In the expert group, they study the assigned question/task together, discuss and share information on their topic until they complete the task and get the answer. They take notes to help them in teaching home group members

HOME GROUP REPORTING: Students return to their original jigsaw groups to teach the remaining members what they have learnt in the expert group on their topic. Each member listens, contribute, ask questions and take notes on what each expert discusses.

As the group work progresses, the teacher goes round the groups to give assistance, encourage and praise collaborative skills and learn more about the students..

WHOLE CLASS DISCUSSION: The teacher allows a brief whole class discussion to clear doubts, if any, as well as provoke further discussion on the topic.

EVALUATION: Students are given quiz on the topics they have learnt in their jigsaw groups.

1. A closed cylindrical pipe is 20cm long with radius 10cm. find the total surface area of the cylinder.
2. A solid cylinder with height 12cm has a total surface area of 341cm^2. Find its diameter.

3. The diameters of two cylindrical pipes are in the ratio 6:5 while their heights are in the ratio 7:10. What is the ratio of their curved surface areas.

GROUP RECOGNITION: Students exchange their scripts. The teacher provides marking guide on the board and students mark the scripts. The 2$^{nd\ t}$ lesson quiz score is used as base score and individual improvement score calculated by the students, from which each group's average improvement score is obtained. The group with the highest average improvement score receives a group reward.

CLOSURE: Students clap for themselves for the day's work and teacher assigns each group member a task/question on the expert sheet for next lesson so that students read as home work to save time for the next lesson.

WEEK 4 (LESSON 4: VOLUME OF A CUBE)

PRELIMINARY INFORMATION

Subject: Mathematics

Class: SS1

Time: 80 minutes

Content: Volume of a cube

Materials: Objects that are cubes and cuboids in shape, both real and models. MAN Mathematics for Senior Secondary Schools for SS 1 – Chapter 17 on surface area and volumes of cube, cuboid and cylinder, expert sheets containing 4 questions on 4 sub-topics of volume of a cube.

BEHAVIOURAL OBJECTIVES: At the end of the lesson, students will be able to:

- Calculate the volume of a cube
- Calculate the length of a cube given the volume
- Compare volumes of cubes

CHOOSING GROUPS: The teacher uses previous heterogeneous groupings with necessary adjustments based on his observations in last lesson. Each group will contain 4 students with high, medium and low ability level students. These original groups are called jigsaw or home groups.

PRESENTING THE CONTENT:

- Teacher distributes lesson materials to students and assigns group roles to students using numbed heads (Each student is assigned a number from 1 to 4. 1's is for team leader, 2's for recorder, 3's for checker and 4's for timekeeper).
- Task assignment: Teacher assigns one task/question from the expert sheet on different sub-topics of volume of a cube using numbered heads to each of the 4 members of the original jigsaw group.

- Students review co-operative learning roles responsibilities and ground rules for group work written and pasted on the board while the teacher explains the jigsaw II co-operative learning procedures.

  READING: Each member focus on reading the portion of the learning material assigned to him or her for some time.

EXPERT GROUP DISCUSSION: Each member in the home group meets other members assigned the same task to form expert group. In the expert group, they study the assigned

question/task together, discuss and share information on their topic until they complete the task and get the answer. They take notes to help them in teaching home group members

HOME GROUP REPORTING: Students return to their original jigsaw groups to teach the remaining members what they have learnt in the expert group on their topic. Each member listens, contribute, ask questions and take notes on what each expert discusses.

As the group work progresses, the teacher goes round the groups to give assistance, encourage and praise collaborative skills and learn more about the students..

WHOLE CLASS DISCUSSION: The teacher allows a brief whole class discussion to clear doubts, if any, as well as provoke further discussion on the topic.

EVALUATION: Students are given short quiz on the topics they have learnt in their jigsaw groups.

1. A cube is 4cm long. Calculate its volume.
2. The volume of a cube is 1331cm^3. Find the base area of the cube
3. The volumes of two cubes are in the ratio 27: 125. What is the ratio of their heights?

GROUP RECOGNITION: Students exchange their scripts. The teacher provides marking guide on the board and students mark the scripts. The $3^{rd\ t}$ lesson quiz score is used as base score and individual improvement score calculated by the students, from which each group's average improvement score is obtained. The group with the highest average improvement score receives a group reward.

CLOSURE: Students clap for themselves for the day's work and teacher assigns each group member a task/question on the expert sheet for next lesson so that students read as home work to save time for the next lesson.

WEEK 5 (LESSON 5: VOLUME OF A CUBOID)

PRELIMINARY INFORMATION

Subject: Mathematics

Class: SS1

Time: 80 minutes

Content: Volume of a cuboid

Materials: Materials: Objects that are cubes and cuboids in shape, both real and models. MAN Mathematics for Senior Secondary Schools for SS 1 – Chapter 17 on surface area and volumes of cube, cuboid and cylinder, expert sheets containing 4 questions on 4 sub-topics on volume of a cuboid

BEHAVIOURAL OBJECTIVES: At the end of the lesson, students will be able to:

- Calculate the volume of a cuboid
- Find unknown side of a cuboid given the volume and any other 2 sides
- Solve problems on addition/subtraction of volumes involving cuboid
- Calculate the volume of similar cuboids

CHOOSING GROUPS: The teacher uses previous heterogeneous groupings with necessary adjustments based on his observations in the last lessons. Each group will contain 4 students with

high, medium and low ability level students. These original groups are called jigsaw or home groups

PRESENTING THE CONTENT:

- Teacher distributes lesson materials to students and assigns group roles to students using numbed heads (Each student is assigned a number from 1 to 4. 1's is for team leader, 2's for recorder, 3's for checker and 4's for timekeeper).

- Task assignment: Teacher assigns one task/question from the expert sheet on different sub-topics of volume of a cube using numbered heads to each of the 4 members of the original jigsaw group.
- Students review co-operative learning roles responsibilities and ground rules for group work written and pasted on the board while the teacher explains the jigsaw II co-operative learning procedures.

  READING: Each member focus on reading the portion of the material assigned to him or her for some time.

EXPERT GROUP DISCUSSION: Each member in the home group meets other members assigned the same task to form expert group. In the expert group, they study the assigned question/task together, discuss and share information on their topic until they complete the task and get the answer. They take notes to help them in teaching home group members

HOME GROUP REPORTING: Students return to their original jigsaw groups to teach the remaining members what they have learnt in the expert group on their topic. Each member listens, contribute, ask questions and take notes on what each expert discusses.

As the group work progresses, the teacher goes round the groups to give assistance, encourage and praise collaborative skills and learn more about the students..

WHOLE CLASS DISCUSSION: The teacher allows a brief whole class discussion to clear doubts, if any, as well as provoke further discussion on the topic.

EVALUATION: Students to solve these problems as quiz:

1. Find the volume of a cuboid 1.8m long, 2.4m wide and 2.5m high.
2. A cuboid holds 1 litre of water. If its base is 12.5cm by 20cm, calculate the height of the cuboid.
3. An open rectangular box made of wood 1.5 cm thick is measures externally 63cm by 48cm by 50cm. Calculate: (a) the volume of wood in the box (b) the mass of the box if the density of the wood is $0.8g/cm^3$

GROUP RECOGNITION: Students exchange their scripts. The teacher provides marking guide on the board and students mark the scripts. The 4^{th} lesson quiz score is used as base score and individual improvement score calculated by the students, from which each group's average improvement score is obtained. The group with the highest average improvement score receives a group reward.

CLOSURE: Students clap for themselves for the day's work and teacher assigns each group member a task/question on the expert sheet for next lesson so that students read as home work to save time for the next lesson.

WEEK 6 (LESSON 6: VOLUME OF CYLINDER)

PRELIMINARY INFORMATION

Subject: Mathematics

Class: SS1

Time: 80 minutes

Content: Volume of cylinder

Materials: Objects that are cylindrical in shape, both real and models. MAN Mathematics for Senior Secondary Schools for SS 1 – Chapter 17 on surface area and volumes of cube, cuboid and cylinder, expert sheets containing 4 questions on 4 sub-topics of volume of cylinder.

BEHAVIOURAL OBJECTIVES: At the end of the lesson, students will be able to:

- Find the volume of a cylinder
- Find unknown value (radius or height) of a cylinder given the volume and the other value
- Solve problems on addition/subtraction of volumes involving cylinder
- Calculate volumes of similar cylinders

CHOOSING GROUPS: The teacher uses previous heterogeneous groupings with necessary adjustments based on his observations in the last lessons. Each group will contain 4 students with high, medium and low ability level students. These original groups are called jigsaw or home groups.

PRESENTING THE CONTENT:

- Teacher distributes lesson materials to students and assigns group roles to students using numbed heads (Each student is assigned a number from 1 to 4. 1's is for team leader, 2's for recorder, 3's for checker and 4's for timekeeper).
- Task assignment: Teacher assigns one task/question from the expert sheet on different sub-topics of volume of a cylinder using numbered heads to each of the 4 members of the original jigsaw group.
- Students review co-operative learning roles responsibilities and ground rules for group work written and pasted on the board while the teacher explains the jigsaw II co-operative learning procedures.

READING: Each member focus on reading the portion of the material assigned to him or her for some time.

EXPERT GROUP DISCUSSION: Each member in the home group meets other members assigned the same task to form expert group. In the expert group, they study the assigned question/task together, discuss and share information on their topic until they complete the task and get the answer. They take notes to help them in teaching home group members

HOME GROUP REPORTING: Students return to their original jigsaw groups to teach the remaining members what they have learnt in the expert group on their topic. Each member listens, contribute, ask questions and take notes on what each expert discusses.

As the group work progresses, the teacher goes round the groups to give assistance, encourage and praise collaborative skills and learn more about the students.

WHOLE CLASS DISCUSSION: The teacher allows a brief whole class discussion to clear doubts, if any, as well as provoke further discussion on the topic.

EVALUATION: Students are given quiz on the topics they have learnt in their jigsaw groups.

1. A cylindrical funnel has a base diameter 12cm and a vertical height 30m. calculate its volume.
2. A cylindrical pipe is 28cm long. Its internal radius is 3.5cm with external radius of 5cm. Calculate the volume of material used in making the pipe.
3. The volume of a cylinder is $216cm^3$. A similar cylinder has a volume of $125cm^3$. If the height of the smaller cylinder is 25cm, how long is the larger cylinder?

GROUP RECOGNITION: Students exchange their scripts. The teacher providesss marking guide on the board and students mark the scripts. The 5^{th} lesson quiz score is used as base score and individual improvement score calculated by the students, from which each group's average improvement score is obtained. The group with the highest average improvement score receives a group reward.

CLOSURE: Students clap for themselves for the day's work and teacher assigns each group member a task/question on the expert sheet for next lesson so that students read as home work to save time for the next lesson

APPENDIX G

EXPERT SHEET FOR EXPERT GROUP DISCUSSION (LESSON 1)

Instruction: You will be assigned one of the following tasks. Once a task is assigned, you are to meet those students assigned the same task to form expert group and discuss the question together until its solution is obtained. Make sure you jot down the solution and some important points to be raised during the discussion to help you in teaching your home group members

TASK 1: Calculate the surface area of a cube whose length is 7cm

TASK 2: The surface area of a cube is 1350cm^2. Calculate the height of the cube.

TASK 3: The heights of two cubes are in the ratio 3:7. What is the ratio of their surface areas?

TASK 4: A tank is in form of a cube length 7m. How much will it cost to cover the tank with a cloth if a m^2 of the cloth costs #220.

EXPERT SHEET FOR EXPERT GROUP DISCUSSION (LESSON 2)

Instruction: You will be assigned one of the following tasks. Once a task is assigned, you are to meet those students assigned the same task to form expert group and discuss the question together until its solution is obtained. Make sure you jot down the solution and some important points to be raised during the discussion to help you in teaching your home group members

TASK 1: Calculate the total surface area of a cuboid of length 25cm, breadth 20cm and height 15cm.

TASK 2: A closed matchbox has a surface area of $340cm^2$. If the base of the box is 10cm by 8cm, find the height of the box.

TASK 3: A wooden cuboid is 3.2m long and 2m high. If its surface area is 28.4 cm^2, find the width of the cuboid.

TASK 4: A cuboid is 10cm by 8cm by 7cm. if the cuboid is re-casted into a cube with equal surface area as the cuboid. Find the length of the cube

EXPERT SHEET FOR EXPERT GROUP DISCUSSION (LESSON 3)

Instruction: You will be assigned one of the following tasks. Once a task is assigned, you are to meet those students assigned the same task to form expert group and discuss the question together until its solution is obtained. Make sure you jot down the solution and some important points to be raised during the discussion to help you in teaching your home group members

TASK 1: Calculate the total surface area of a cylindrical tin whose diameter is 21cm and height 12cm.

TASK 2: A solid cylinder with base radius 3.5cm has a total surface area of $341cm^2$. Calculate its height

.

TASK 3: A cylinder height 10cm is 28cm in diameter. What is the difference between its curved surface area and its total surface area?

TASK 4: The heights of two cylindrical drums are in the ratio 7:8 and their base radii are in the ratio 4:3. What is the ratio of their curved surface area

EXPERT SHEET FOR EXPERT GROUP DISCUSSION (LESSON 4)

Instruction: You will be assigned one of the following tasks. Once a task is assigned, you are to meet those students assigned the same task to form expert group and discuss the question together until its solution is obtained. Make sure you jot down the solution and some important points to be raised during the discussion to help you in teaching your home group members

TASK 1: Calculate the volume of a cube of height 2.5m.

TASK 2: If the volume of a cube is $2197m^3$, find its length.

TASK 3: The volumes of two cubes are in the ratio 216: 1331. What is the difference between the lengths of the two cubes?

TASK 4: A tank 150cm high is in form of a cube. If it is half – filled with petrol, how many litres of petrol is it holding

EXPERT SHEET FOR EXPERT GROUP DISCUSSION (LESSON 5)

Instruction: You will be assigned one of the following tasks. Once a task is assigned, you are to meet those students assigned the same task to form expert group and discuss the question together until its solution is obtained. Make sure you jot down the solution and some important points to be raised during the discussion to help you in teaching your home group members.

TASK 1: A rectangular tank is 86cm by 60cm by 50cm. How many litres of petrol can it hold?

TASK 2: The volume of a cuboid is $0.48m^3$. If its dimension is 1.5m by 0.5m by x, What is the value of x?

TASK 3: Two similar rectangular boxes have volumes of $250cm^3$ and $54cm^3$. What is the ratio of their heights?

TASK 4: An open rectangular box measures externally 32cm long, 27cm wide and 15cm deep. If the box is made of wood 1cm thick, what volume of wood is used to make the box?

EXPERT SHEET FOR EXPERT GROUP DISCUSSION (LESSON 6)

Instruction: You will be assigned one of the following tasks. Once a task is assigned, you are to meet those students assigned the same task to form expert group and discuss the question together until its solution is obtained. Make sure you jot down the solution and some important points to be raised during the discussion to help you in teaching your home group members.

TASK 1: A cylindrical well of radius 1m is dug out to a depth of 8m. Calculate, in m^3, the volume of soil dug out.

TASK 2: 154 litres of oil is poured into a cylindrical barrel of diameter 35cm. To what depth is the drum filled?

TASK 3: A cylindrical pipe is 28m long. Its internal diameter is 7cm with external diameter of 10cm. Calculate the volume of material, in cm^3 , used in making the pipe.

TASK 4: If an oil drum with capacity of 25 litres is 60cm deep, find the depth of a similar drum which holds 1.6 litres.