EFFECTS OF COOPERATIVE LEARNING STRATEGY AND SEX ON STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY IN DELTA CENTRAL SENATORIAL DISTRICT

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DELTA STATE UNIVERSITY, ABRAKA

NOVEMBER, 2018

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF EDUCATION, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS OF EDUCATION (M.Ed.) DEGREE IN SCIENCE EDUCATION (CHEMISTRY)

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NOVEMBER, 2018

DECLARATION

I, **AKPOCHIMORA, Florence** declare that this research work "effects of cooperative learning strategy and sex on students' academic achievement in chemistry in Delta Central Senatorial District" was written by in the Department of Science Education, Delta State University, Abraka. This dissertation has not been submitted to this institution or any other institution for the award of a degree.

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Akpochiomora Florence   Date

PG/14/15/229502

CERTIFICATION

This is to certify that this research work “effects of cooperative learning strategy and sex on students’ academic achievement in chemistry in Delta Central Senatorial District” was written by **AKPOCHIMORA, Florence,** in the Department of Science Education, Delta State University, Abraka..

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DEDICATION

This research work is dedicated to my lovely parents, Mr. and Mrs. Oghoufo

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ABSTRACT

This study investigated the effects of cooperative learning strategy and sex on students' academic achievement in chemistry in Delta Central Senatorial District. Nine research questions and nine hypotheses guided the study. The study adopted the non-equivalent pre-test, posttest control group design. A sample size of 363 senior secondary two (SS II) Chemistry students from eight public mixed secondary schools in Delta Central Senatorial District was used for the study. The instrument for data collection was the Chemistry Achievement Test (CAT). The reliability of the instrument was established using Kuder-Richardson formula 21 which yielded coefficient of internal consistency of 0.77. Data were collected by administering the Chemistry Achievement Test (CAT) as pretest and posttest. The data obtained were analyzed using mean, standard deviation, independent sample t-test, Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA). The results showed that there was a significant difference between the mean achievement scores of students taught chemistry with cooperative learning instructional strategy and those taught using lecture method, in favour of the cooperative learning group; there was no significant difference between the mean achievement scores of male and female students in urban and rural schools taught chemistry using cooperative learning instructional strategy; there was a significant difference between the mean achievement scores of students in urban and rural schools taught chemistry using cooperative learning instructional strategy, in favour of students in urban schools. The results also showed that there was no significant effect of interaction among sex, school location and teaching method on achievement scores in CAT. It was recommended that chemistry teachers should adopt cooperative learning instructional strategy in the teaching of chemistry concepts. Also, special training on the effective implementation of cooperative learning strategy should be organized for teachers by government.

CHAPTER ONE

INTRODUCTION

Background to the Study

Chemistry is the branch of science that deals with the properties, syntheses and uses of matter. The various branches of Chemistry include: Biochemistry, Geochemistry, Organic-chemistry, Physical chemistry, Industrial chemistry, chemistry of earth and space, inorganic chemistry, and medical chemistry. It is one of the science subjects taught in secondary schools and in the university. According to Igwe (2002), the objectives of secondary school chemistry curriculum as specified in the senior secondary school syllabus are as follows:

a. to facilitate transition in the use of scientific concepts and techniques acquired integrated science (now basic science) with chemistry;

b. to provide basic knowledge in chemistry concepts and principles through efficient selection of contents and sequencing;

c. to show inter-relationships between chemistry and other science subjects;

d. to show chemistry and its link with the industry, everyday life, hazards and benefits, and;

e. to provide students not proceeding for higher education with adequate foundation for other future careers.

The importance of chemistry to national development is inexhaustible. The teaching of chemistry helps to imbibe scientific knowledge and stimulate science oriented attitude in learners. This attitude when directed to the world of work results in the development of the individual, the society and general standard of living of the citizenry (Igwe, 2015). According to the national policy on education, science education should develop in the child well defined abilities and values such as the spirit of inquiry, creativity, objectivity, the courage to question, and an aesthetic sensibility (Federal Republic of Nigeria, 2004). The policy further stated that science education programmes are designed to enable the learner to acquire problem-solving and decision-making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life (Federal Republic of Nigeria, 2004). The idea therefore is that of practicing science not just learning the concept. To be able to achieve these objectives it requires proper conceptualization of chemistry concepts. This would require teaching and learning approaches such as cooperative learning strategy that could make students practice science knowledge gained, achieve good grades and apply the learned concepts in their daily lives as would be scientists.

Co-operative learning strategy represents a shift from the typical teacher-centred or lecture-centred learning. In cooperative learning strategy, students are arranged in pairs or small groups to help each other learn assigned material (Trowbridge & Bybee, 1996). Interaction among students in cooperative learning groups is intense and prolonged (Borich, 2004). Unlike self-directed inquiry, in cooperative learning groups, students gradually take responsibility for each other's learning (Ajaja, 2013). Trowbridge and Bybee (1996) identified four basic elements in cooperative learning models. These basic elements include: small groups must be structured for positive interdependence, face-to-face interactions, individual accountability, and use of interpersonal and small group skills. Cooperative learning strategy has been found to be very useful in several areas and prominent among them are: helping learners to acquire from the curriculum the basic cooperative attitudes and values they need to think independently inside and outside the classroom (Johnson, Johnson & Holubec, 1990); promoting the communication of pre-social behaviour, encouraging high thought processes and fostering concept understanding and achievement (Ajaja, 2013). Cooperative learning strategy brings together in adult like settings which, when carefully planned and executed can provide appropriate models of social behaviour (Stevens & Slavin, 1995). Stevens & Slavin (1995), stressing the importance of cooperative learning strategy, noted that if all of the preceding benefits of cooperative learning strategy were not enough, the fact that it has been linked to increase in the academic achievement of learners at all ability levels is another reason for its use. Cooperative learning is known to actively engage students in the learning process and seeks to improve the critical thinking, reasoning, and problem solving skills of the leaner (Bramlett, 1994; Megnin, 1995;). Research-based evidence has shown that cooperative learning strategy improves students' learning outcome and educators have recognized cooperative learning strategy as a beneficial teaching-learning technique for different subjects (Zakaria, Solfitri, Daud & Abidin, 2013). Cooperative learning strategy was found by Wayne (2013) to have positive effects on academic achievement when students are accountable only to themselves, when they are accountable to both themselves and their group, and when they are solely accountable to their group. Rose (2014) further found that cooperative learning strategy had positive effect on students' mathematics achievement.

Over the years, the predominant method of instruction in chemistry has been the lecture method (Nwabufor, 2005). Lecture method is a teacher-centred approach to teaching and learning in which the teacher is seen as an authority, dispensing knowledge to students who contribute little or nothing to the instruction. Lecture method has been criticized by Adegoke (2011) who posited that only hardworking students can benefit from it. The classrooms in Nigeria are predominantly dominated by lecture method of instruction which does not encourage students-students interaction. The common use of lecture method is obviously due to the fact that it is suitable for teaching a large number of students and saves a lot of time. It also requires lesser skill on the part of the teachers who use the approach. Lecture method as a teacher-centred approach makes for students' passivity and therefore leads often times to poor academic achievement.

The issue of poor academic achievement seems to be the central issue in most science education research. Most of the researches aim at finding lasting solution to students' continuous under-achievement reported and blamed students' under-achievement on rote learning as a result of the use of lecture method. None of the studies however, has focused on the students' interaction among themselves and the teachers and how such relationship can affect chemistry achievement.

Sex refers to those characteristics of males or females which are biologically determined such as possession of penis by males and vagina by females (Okeke, 2008). Sex is a major factor that influences career choice and subject interest of students. Okeke (2008) described the males' attributes as bold, aggressive, tactful, economical use of words while the females are fearful, timid, gentle, dull, submissive and talkative. May be that is the reason Umoh (2003) stated that more difficult works are usually reserved for males while the females are considered feminine in a natural setting. Thus, in schools, males are more likely to take to difficult subject areas like science (chemistry) while the females take to career that will not conflict with marriage chances, marriage responsibilities and motherhood (Okeke 2008). The reports on sex as a predicting factor of students' achievement in sciences are mixed. While some findings indicated no significant effect of sex in science achievement (Olatoye, 2009; Adekoya, 2010), some researchers reported significant influence of sex on academic achievement with boys having better scores than girls in the study.

The concept of school location refers to schools that are located in rural or urban areas. According to Orji (2013), school location refers to rural and urban schools. Thus, Orji further conceptualized urban schools as those schools in the municipalities or schools found within the towns and rural schools as those located in the villages or semi-urban areas. In addition, Frederick (2011) views school location as one of the major factors that influence students' academic achievement in some subject areas. As such, Frederick added that many parents look at factor such as the location of schools (urban or rural) and the distance to the school before enrolling their wards. To that end, Owoeye and Yara (2011) noted that many parents prefer their children to attend schools in urban areas because they (parents) believe that students from urban schools perform better than their counterparts from rural schools. Thus, Orji (2013) explained that many students in the interior villages struggle with the challenge of walking a long distance to school. The implication is that while people in some urban areas convey their children to school through vehicle and enjoy minimum travelling distances to acquire education, some people in other places suffer by having to cover maximum distances to acquire education; some people in some rural places suffer by having to cover maximum distances to get to their school (Ezeudu, Olaowei & Umeifekwem, 2014). According to Orji, this may have contributed significantly to students' poor achievement in some rural schools. Throwing light on locational influence, Onuoha (2010) noted that school location is one of the potent factors that influence the distribution of educational resources and academic achievement. Writing on locational influence on academic achievement of students, Frederick (2011) observed a significant difference in urban-rural achievement and that location exerted some significant measure of influence on students' achievement in Agricultural Science Achievement Test (ASAT). Giving credence to the above, Owoeye and Yara (2011) found a significant difference in the academic achievement of students in urban and rural areas in senior school certificate examinations.

In this study however, the researcher sought to ascertain if the use of cooperative learning strategy could improve chemistry students' academic achievement with school location as moderating variables. The study also sought to determine the effect of sex on students' achievement in chemistry. Against this background, this study was designed to determine the effects of cooperative learning strategy and sex on students' academic achievement in chemistry in Delta Central Senatorial District of Delta State.

Statement of the Problem

The fact that students' academic achievement in chemistry at the secondary school level has remained a dismal failure is no longer new. Several researchers have reported a continuous decline in the achievement of Nigerian students in chemistry. However, data from various external examination bodies such as the West African Examination Council (WAEC) and the National Examination Council (NECO) have shown a consistent trend of poor performance of students in chemistry.

Students' poor academic achievement in chemistry may be attributed to various factors among which is poor teaching methods and sex. The lecture method most predominantly use in Nigerian secondary schools have made students resort to memorization of chemistry contents as a result of their passive involvement in the teaching and learning process. Chemistry as a subject at the secondary school level contains difficult contents that demand students' active involvement and interaction for proper comprehension.

Students' active involvement as well as active interaction with fellow students, teacher and learning materials is a prerequisite for proper conceptualization of chemistry contents. Cooperative learning strategy ensures active involvement of students in the teaching and learning process and also provides the opportunity for students to discover new knowledge on their own with little or no assistance from teachers. Cooperative learning instructional strategy also encourage students' discovery of new knowledge on their own. The problem of this study therefore, is: what is the effect of cooperative learning strategy and sex on students' academic achievement in chemistry?

Research Questions

The following research questions were raised to guide the study:

1. Is there any difference between the mean achievement scores of students taught chemistry with co-operative learning strategy and those taught with lecture method?
2. Is there any difference between the mean achievement scores of female students taught chemistry with co-operative learning strategy and those taught with lecture method?

3. Is there any difference between the mean achievement scores of male students taught chemistry with co-operative learning strategy and those taught with lecture method?
4. Is there any difference between the mean achievement scores of students in urban and rural schools taught chemistry using co-operative learning strategy?
5. Is there any difference between the mean achievement scores of male and female students in urban school taught chemistry using co-operative learning strategy?
6. Is there any difference between the mean achievement scores of male and female students in rural school taught chemistry using co-operative learning strategy?
7. Is there any effect of interaction of sex and teaching methods on students' achievement in chemistry?
8. Is there any effect of interaction of school location and teaching methods on students' achievement in chemistry?
9. Is there any effect of interaction of sex, school location and teaching methods on students' achievement in chemistry?

Hypotheses

The following hypotheses were raised to direct the study and were tested at 0.05 level of significance.

H_{o1} There is no significant difference between the mean achievement scores of chemistry students taught with co-operative learning strategy and those taught with lecture method.

H_{o2} There is no significant difference between the mean achievement scores of female students taught chemistry with co-operative learning strategy and those taught with lecture method.

H_{o3} There is no significant difference between the mean achievement scores of male students taught chemistry with co-operative learning strategy and those taught with lecture method.

H_{o4} There is no significant difference between the mean achievement scores of students in urban and rural schools taught chemistry using co-operative learning strategy.

H_{o5} There is no significant difference in the mean achievement scores of male and female students in urban school taught chemistry using co-operative learning strategy.

H_{o6} There is no significant difference in the mean achievement scores of male and female students in rural school taught chemistry using co-operative learning strategy.

H_{o7} There is no significant effect of interaction of sex and teaching methods on students' achievement in chemistry.

H_{o8} There is no significant effect of interaction of school location and teaching methods on students' achievement in chemistry.

H_{o9} There is no significant effect of interaction of sex, school location and teaching methods on students' achievement in chemistry.

Purpose of the Study

The purpose of this study was to examine the effects of cooperative learning strategy and sex on secondary school students' academic achievement in chemistry.

Specifically, the study sought to determine;

a. if there is a difference between the mean achievement scores of chemistry students taught with co-operative learning strategy and those taught with lecture method;

b. if there is a difference between the mean achievement scores of female students taught chemistry with co-operative learning strategy and those taught with lecture method;

c. if there is a difference between the mean achievement scores of male students taught chemistry with co-operative learning strategy and those taught with lecture method;

d. if there is a difference between the mean achievement scores of students in urban and rural schools taught chemistry using co-operative learning strategy;

e. if there is a difference between the mean achievement scores of male and female students in urban school taught chemistry using cooperative learning strategy;

f. if there is a difference in the mean achievement scores of male and female students in rural school taught chemistry using cooperative learning strategy;

g. if there is an effect of interaction of sex and teaching methods on students' achievement in chemistry;

h. if there is an effect of interaction of school location and teaching methods on students' achievement in chemistry;

i. if there is an effect of interaction of sex, school location and teaching methods on students' achievement in chemistry.

Significance of the Study

The findings of this study may be beneficial to chemistry students, chemistry teachers, textbook writers, ministry of education, curriculum planners and chemistry education researchers.

The outcome of this study may help chemistry students appreciate how the interaction among themselves and their teachers affect their academic achievement. It help students in developing adequate inter-personal relationships as a result of students interacting with their peers.

The outcome of this study may stimulate chemistry teachers to adopt the cooperative instructional strategy. The findings of the study may reveal the benefits underlying co-operative learning strategy and how it can ease the teaching of chemistry while improving students' achievement.

The findings of this study may encourage chemistry textbook writers to design and arrange subject matter contents in such a way that it could facilitate cooperative learning without requiring extra effort from the teachers and to allocate more time in arranging learning experiences to facilitate learning.

The outcome of this study may draw the attention of the Ministry of Education to the gap that exists between chemistry instruction and students performance. This may stimulate the ministry of education to organize in-service training to teachers to acquaint them with effective implementation of innovative teaching method.

The outcome of this study may serve as an eye opener to chemistry curriculum planners on the effect of co-operative learning strategy on students' achievement in chemistry. This may stimulate chemistry curriculum planners to inculcate in the curriculum students' activities that facilitate cooperative learning among students.

The outcome of this study may enrich chemistry literature on the effects of cooperative learning strategy and sex on students' academic achievement. This may serve as guide for future chemistry education researchers in stating research questions, hypotheses as well as selecting appropriate methodology for their studies.

Scope and Delimitation of the Study

The study focused on the effects of cooperative learning strategy and sex on the academic achievement of senior secondary two (SSII) chemistry students in the following selected chemistry contents:

1. electronic configuration and occurrence of sulphur;
2. laboratory and industrial preparation of sulphur;
3. physical and chemical properties of sulphur;
4. uses of sulphur; preparation of H_2SO_4;

This study is delimited to all public mixed senior secondary schools in Delta Central Senatorial District. Specifically, the study covered eight (8) selected public mixed secondary schools (4 urban and 4 rural) in Delta Central Senatorial District of Delta State.

Limitations of the Study

The limitations of this study include:

1. The nature of the research design which was quasi-experiment, only eight schools out of one hundred and seventy nine (179) public secondary schools in Delta Central Senatorial District of Delta state were used. The study may have more generalized effect if more schools in the Senatorial District were used.
2. The time allocated to chemistry in the school time table may have constituted a barrier in implementing cooperative learning instructional strategy. This in turn may have affected the academic achievement of the slow learners.
3. The non-familiarization of cooperative learning instructional strategy to students constituted a problem to students in the first two weeks of treatment. This may have affected the academic achievement of students taught chemistry using the cooperative learning instructional strategy.

Operational Definition of Terms

Cooperative Learning strategy: Cooperative learning strategy is a teaching strategy whereby students are arranged in pairs or small groups to help each other learn assigned materials. The students were heterogeneously grouped.

Lecture Method: It is teaching method in which the teacher transmits knowledge in the finite form to students. The students are given little or no opportunity to ask questions during the teaching and learning process.

Sex: Male or female students.

School Location: Environment where a school is located.

Academic Achievement: Students scores in standardized test or examination.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter dealt with the review of related literature. The review was organized under the following sub-headings:

- Theoretical Framework of the Study
- Concept of Cooperative Learning Strategy
- Forms of Cooperative Learning
- Methods of Teaching Chemistry in Secondary Schools
- Effective Implementation of Cooperative Learning Strategy
- Empirical Studies on the Effects of Cooperative Learning Strategy on Students' Academic Achievement in Chemistry
- Empirical Studies on the Effect of sex on Academic Achievement of Chemistry Students
- Empirical Studies on the Effect of School Location on Academic Achievement of Chemistry Students
- Appraisal of the Reviewed Literature

Theoretical Framework of the Study

This section discussed the educational theory that anchored this study. The theory of interest is Bandura (1977) Social learning theory. This theory focuses on the learning that occurs within a social context. It posits that people learn from one another by observing and imitating the behaviour of others. Classroom as part of the social order of the school social system employs students' interaction and engagement in the teaching-learning process to enhance students learning. This environment conforms to the social learning theory of Albert Bandura (1977).

The Bandura (1977) social learning theory consists of the following principles:

- **Attention:** We cannot learn if we are not focused on a task

- **Retention:** We learn by internalizing information in our memories which is recall later when we are required to respond to a situation.
- We reproduce previously learnt information (behaviour, skills, knowledge) when required.
- **Motivation:** We need to be motivated to do something often. That motivation originates from our observation of someone else being rewarded.

The application of this social learning theory in the classrooms allows teachers to use two types of students grouping:

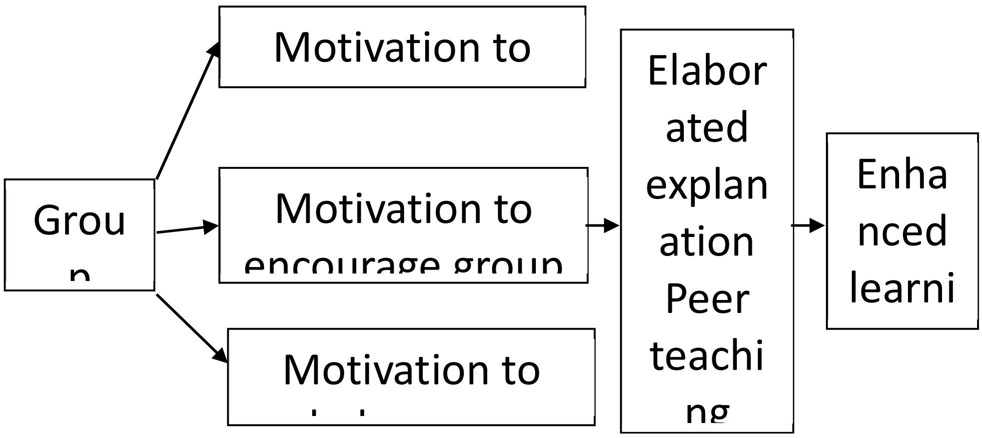
- First, the heterogeneous grouping where students of different abilities are combined.
- Secondly, the homogenous grouping of students of similar abilities.

Kagan (2010) laid more emphasis on the social learning theory using the Kagan cooperative learning model. Kagan (2010) defined cooperative learning strategy as "a teaching arrangement that refers to small, heterogeneous group of students working together to achieve a common goal". The Kagan model of cooperative learning is based on the concept and use of structures. He defined structure as an instructional strategy that describes how the teacher and students interact with the content of the lessons to create greater engagement and learning for all students. The teacher is not expected to plan cooperative lesson but make cooperative learning part of the lesson. The implication of Kagan's cooperative learning model to this study is that the heterogeneous and homogeneous forms of student's grouping within the teaching-learning process were implemented as structures.

The implication of Bandura's social learning theory to this study is as follows:

1. This study, effect of cooperative learning strategy and sex on students' academic achievement which is based on Kagan's cooperative model employed cooperation and social behaviour of students in the learning process.

2. The four principles of social learning theory application in the classroom were adopted in the application of Kagan's cooperative learning model as shown below.



Slavin 1996 in Davoudi & Mahinpo (2012)

3. The heterogeneous and homogeneous grouping of students of social learning classroom environment was adapted in the implementation of Kagan's structures of cooperative learning in this study.

Concept of Cooperative Learning Strategy

The term 'cooperative learning strategy' refers to an instructional method in which students at various achievement or ability levels work together in small groups toward a common goal (Gokhale, 1995). The students are responsible for one another's learning as well as their own. Therefore, the success of one student helps another student to be successful. Through cross modeling and role playing, students are encouraged to draw on their individual experiences and background knowledge to create a common product. The social context created by the cooperative learning strategy allows students to shape ideas, modify them by listening to peers, question, express doubt, and jointly design and implement plans. Slavin (1996) stated that the social dividends include positive interdependence, heterogeneity, and shared visions and responsibilities. The authentic learning environment of cooperative learning strategies also enhances potentials for transfer to team based activities in professional practice (Johnson & Johnson, 1994). The concept of cooperative learning strategy has also been described, as a social situation in which the goals of separate individuals are so linked together that an individual can attain his/her goal only if the other persons with whom he/she is cooperatively linked to attain theirs as well (Olarewaju, 2012). As an instructional technique, cooperative learning strategy requires students to work together in small groups (usually 4-6 members), and are rewarded for their performance as a group. The concept of cooperative learning strategy therefore, stems from the prevailing principles that learners in a cohesive group, work mutually together for the attainment of set educational objectives (Olarewaju, 2012). The underlying principle here is that there is social cohesion and the willingness of members of the group to work together. The cooperative learning strategy works on this principle to encourage students working in groups to achieve lesson objectives in science under the guidance of the teacher.

Johnson and Johnson (1999) also define cooperative learning strategy as the instructional use for small groups in which pupils/students work together to maximize and gain from each other. In cooperative learning strategy, pupils are expected to help, discuss and argue with each other, assess each other’s current knowledge, and fill any gaps in each other's understanding (Slavin, 1996). Students who participate in cooperative learning have been shown to perform significantly better on critical thinking than students who studied individually.

Bruffee (1995) sees cooperative learning strategy as a set of processes that help people interact in order to accomplish a specific goal or develop a product, which is usually content specific. Kagan (1989) describes cooperative learning strategy as a small group of learners who work together as a team to solve a problem, complete a task or accomplish a common goal.

When students are in a cooperative learning environment, it is assumed that they seek information and understanding through active mental search without discrimination in gender or ability and the learning is long term (Lefrancois, 1994). Proponents of cooperative learning strategy claimed that the active exchange of ideas within small groups not only increases interest among the participants but promotes critical thinking. According to Johnson and Johnson (1986), there is persuasive evidence that cooperative teams achieve at higher levels of thoughts and retain information longer than the students who work quietly as individuals. Some studies have recommended the efficacy of cooperative structures in that they lead to increase cohesiveness among the students involved, which are beneficial in classes that are diverse in ethnic composition, ability level or because of the inclusion of mainstreamed handicapped students (Crooks, 1988).

There are many different cooperative learning strategies; however, all of them have certain elements in common as established by Johnson, Johnson and Holubec (1990). These elements are the ingredients necessary to ensure that when students work in groups, they work cooperatively. Cooperative learning strategy is not simply a synonym for students working in groups. A learning exercise only qualifies as cooperative learning to the extent that certain elements are present. These elements according to Johnson et al. (1990) are:

Positive Interdependence: - Team members are obliged to rely on one another to achieve the goal. If any team member fails to do their part, everyone suffers the consequences.

Individual Accountability: - All students in a group are held accountable for doing their share of the work and for mastery of all of the material to be learned. Each member of a team is assessed individually. Teammates work together, but the learning gains of individuals form the basis of a team score.

Equal Opportunities for Success: - Individual's improvement over prior performance is more important than reaching a pre-established score (90 percent on a test, for example). A student who moves from 60 percent on a test one week to 68 percent (8 percent improvement) the next week contributes just as much to a group as a student who moves from 82 percent to 90 percent (also 8 percent improvement).

Face-to-face Promotive Interaction:- Although some of the group works may be parceled out and done individually, some must be done interactively, with group members providing one another with feedback, challenging one another's conclusions and reasoning, and perhaps most importantly, teaching and encouraging one another.

Appropriate use of Collaborative Skills: - Students are encouraged and helped to develop and practice trust-building, leadership, decision-making, communication, and conflict management skills.

Group Processing: - Team members set group goals, periodically assess what they are doing well as a team, and identify changes they will make to function more effectively in the future. Teams work to earn recognition for the improvement of each member of a group. The members of a group must perceive that they are part of a team and that they all have a common goal. Group members must realize that the problem they are to solve is a group problem and that the success or failure of the group will be shared by all members of the group. To accomplish the group's goal, all students must talk with one another to engage in discussion of all problems; finally, it must be clear to all that each member's individual work has a direct effect on the group's success. Teamwork is of utmost importance.

However, the ultimate success of cooperative learning is based on a single principle of teaching students how to participate in a group situation. Teachers cannot assume that students know how to behave in a group setting. These elements are the guiding principles of cooperative learning strategy which contribute to the success as a teaching and learning strategy.

Forms of Cooperative Learning Strategy

There are a great number of cooperative learning techniques available. Some cooperative learning techniques utilize student pairing, while others utilize small groups of four or five students. Hundreds of techniques have been created into structures to use in any content area (Kagan, 1994). Among the easy to implement structures are think-pair-share, think-pair-write, variations of Round Robin, and the reciprocal teaching technique (Schul, 2011). A well known cooperative learning technique is the Jigsaw, Jigsaw II and Reverse Jigsaw.

Jigsaw

The jigsaw technique is a method of organizing classroom activity that makes students dependent on each other to succeed. It breaks classes into groups and breaks assignments into pieces that the group assembles to complete the (jigsaw) puzzle. It was designed by social psychologist Elliot Aronson to help weaken racial cliques in forcibly integrated schools (Lestik & Plous, 2012).

The technique splits classes into mixed groups to work on small problems that the group collates into a final outcome (Lestik & Plous, 2012). For example, an in-class assignment is divided into topics. Students are then split into groups with one member assigned to each topic. Working individually, each student learns about his or her topic and presents it to their group. Next, students gather into groups divided by topic. Each member presents again to the topic group. In same-topic groups, students reconcile points of view and synthesize information. They create a final report. Finally, the original groups reconvene and listen to presentations from each member. The final presentations provide all group members with an understanding of their own material, as well as the findings that have emerged from topic-specific group discussion.

Jigsaw II

Jigsaw II is Slavin (1980) variation of Jigsaw in which members of the home group are assigned the same material, but focus on separate portions of the material. Each member must become an "expert" on his or her assigned portion and teach the other members of the home group (Schul, 2011).

Reverse Jigsaw

This is one of the newest methods created by Hedeen (2003) under the cooperative learning techniques used in classroom settings. It follows the same principle as the original Jigsaw method. The jigsaw technique in the cooperative learning methods uses a small group structure to facilitate group discussion through which the learning takes place. The reverse jigsaw method also resembles the original jigsaw method in some way but has its own objectives to be fulfilled (Wikipedia, 2017). While the jigsaw method focuses on the student's comprehension of the Instructor's material, the reverse jigsaw method focuses on the participant's interpretations such as perceptions, judgements through a very active discussion. This method was mainly created to cater for the higher class students. It is best advised to give an explanation before the discussion of the topics takes place. This not only ensures that the learners are more effective in their discussion but also saves time. It differs from the original Jigsaw during the teaching portion of the activity. In the Reverse Jigsaw technique, students in the expert groups teach the whole class rather than return to their home groups to teach the content (Hedeen, 2003).

Process

The process involved in the reverse Jigsaw method can be explained in 3 steps (Wikipedia, 2017):

1. Students gather in mixed groups where they are each given a case study with a number of questions or one complex question and allotted time of about 15 minutes to discuss. Each member of the team is given a unique topic and hence a discussion is initiated within the mixed group and the main points and the outcomes are noted.

2. Each member gather in the expert group or topic group and the points and outcomes are compared. A report is prepared compiling all the common and divergent themes. The time allotted for this could be between 15 - 20 mins. A reporter is appointed to present the same before the class.
3. The class gathers as a whole and the reporters from the individual topic group present their reports to the whole class by ways of Overheads, flipcharts or chalkboard, following which the instructor debriefs the whole exercise with review or evaluation of the process.

Methods of Teaching Chemistry in Secondary Schools

Instructional approaches are systematic procedures employed by teachers in their attempt to ensure that learning takes place. There are various Instructional approaches adopted by Chemistry teachers. Ali (1998) opines that no one approach can be regarded as the best for every teaching situation. According to Dahiru (2006), Chemistry teachers should be aware of certain general rules which facilitate the selection of appropriate approach of imparting knowledge or developing skills in students. Such rules for selecting approaches for teaching a Chemistry lesson include consideration of the students' age, their previous knowledge on the topic and their general ability.

The importance of instructional approach in students' achievement and interest cannot be over emphasized. Onwuka (1984) sees instructional approach as a very vital part of any curriculum which contributes much to the attainment of goals of education. The approach adopted by the teacher according to Igboanugo (2011) promotes or hinders learning. It may sharpen mental activities which are the basis of social power or discourage initiative and curiosity and consequently hinders self reliance and survival.

Many researchers such as Dahiru (2006), Nwachukwu (2008) and Njoku (2009) have identified instructional approach as a major factor responsible for the general apathy towards Chemistry and the perennial poor achievement in the subject. In recent times, researchers have devoted their time seeking for effective instructional approach in Chemistry and other sciences.

The National Policy on Education, FRN (2004) stresses that educational activities shall be centered on the learner for maximum self-development and self-fulfillment. It adds also that modern educational techniques shall be increasingly used and improved upon at all levels of educational system. By this, the National Policy on Education recognizes instructional approaches that are child-centered like cooperative learning and peer- teaching and the policy gives room for continued search for better and improved instructional approaches of realizing educational objectives.

Ugwu (2004) grouped various instructional approaches in Chemistry into three:

(a) Practically-based approach (laboratory, demonstration, inquiry, investigation etc): This approach is teacher-cenetred. It combines telling, showing and doing for the benefits of the students. Its major advantages being (i) training the students to be good observers and(ii) ensuring economy of time and materials.

It has major disadvantages of (i) reducing students to mere observers and (ii) hindering self discovery.

(b) Theoretical-based approach (lecture, seminars etc): This approach involves verbal presentation of subject matter by the teacher with the students at receiving end. The approach is useful in teaching a large class and in encouraging students to be good listeners. The major limitation of the approach is little provisions for meeting the individual needs of students as instruction is directed to the audience.

(c) Instructional approaches that are combination of activities and theory (field trips, play activities etc): These approaches afford students opportunity to explore, conduct and gather information they need in achieving the educational goals under the guidance and supervision of the teacher. The approaches provide direct and first - hand learning experience for the students and thereby develop interest in students. However, the approaches are time consuming and vulnerable to accidents.

Amaefule (1999) reported that the lecture method is predominantly used in teaching Chemistry in Nigeria. This makes students to memorize concepts, principles and chemical equations and unable to apply Chemistry in their daily lives. This results in poor academic achievement in the subject.

Agu (1995) enumerated instructional approaches that can be employed by the teacher to facilitate the achievement of curriculum objectives as: Observation, discussion, discovery, problem solving, peer teaching and team teaching. Each of these has its own characteristics.

Activity-based instructional approach which purely centers on the learner instead of the teacher is advocated for teaching chemistry and other science subjects. This will discourage rote learning, captivate and sustain students' interest and above all inculcate the science process skills in students. This has been found indispensable in the study of Chemistry and enhancing the academic achievement (Anaekwe, 2010).

Nnaka (2006) identifies two main groups of approaches used in teaching Science, Technology and Mathematics (STM) namely: Conventional approaches, and Innovative

Approaches. The conventional approaches, according to the Igbo (2004) include: (a) lecture, (b) demonstration,(c) field trip,(d) project,(e) laboratory,(f) discovery, (g)home work methods. The innovative approaches include: (a) application of advance organizers,(b) cooperative learning , (c)generative learning,(d) concept mapping,(e) analogies,(f) learning cycle, (g) simulation and games,(h) active learning process. The conventional approaches are usually used in STM teaching, while the innovative approaches are the new ideas/strategies of efficaciously accomplishing the goals of teaching STM. Nnaka (2006) advocated for a shift from the conventional approach, of teaching STM to the innovative approaches for the following reasons:

1. Human society is characterized by dynamism and changes. To this end there has been regular shift in thinking and STM practices in recent years. The methodology of instruction for STM cannot but be part of these global shifts in STM pedagogy.

2. Another reason for the shift is to improve the performance profile of students at all levels in STM. The results of international studies in STM continue to confirm the depreciating performance of our students.

International bodies like UNESCO and International Council of Associations for Science Education (ICASE) in recognition of the prominent role STM can play in global development are seriously concerned about the way STM is taught in Africa and suggested for a rethink and a change for appropriate class room strategies. For instance, the prelude of the conference concept paper by ICASE (2009) stated thus as regards the condition of science and technology education in Africa:

The paper recognizes that all is not well within science and technology education and that there are concerns related to its vision, its philosophy, *its purpose, its research, its approach, its way of meeting need, its expected outcomes and most definitely in the manner in which it is taught.*

So far, it has been revealed that students' poor achievement in Chemistry is attributable mainly to the poor conventional approaches. There is a serious concern and call for a change of instructional approach from the conventional approaches in use to more effective instructional approaches. Therefore, this work tended to study the effect of cooperative learning and sex on students' achievement in chemistry. Perhaps the study will proffer solution to the problem of learning difficult concepts in secondary school Chemistry hence the need for this study.

Effective Implementation of Cooperative Learning Strategy in Learning Process

Hinde and Kovac (2001) discuss two courses that introduced team-based learning in different ways. In the second semester of a physical chemistry course for chemistry and chemical engineering majors, biweekly computer-based group work sessions supplemented traditional lectures, and in the second semester of a biophysical chemistry course taken primarily by biochemistry majors, an approach based on group work with occasional supplementary mini-lectures was used. The group sessions in both courses were inquiry-based. The self-selected teams of three or four in the biophysical chemistry course were given guidelines on effective teamwork, and both peer ratings and self-ratings of student achievement on teams contributed to the final course grades. In the physical chemistry course there was little difference in achievement between the class in question and previous classes that had been taught without group work, but this result is not surprising in view of the fact that the group activities were infrequent and most of the defining criteria for cooperative learning were not met. In the biophysical chemistry course the instructor's assessment was that the students gained considerable conceptual understanding and problem solving ability as well as critical thinking and teamwork skills, but no comparison with a control group was carried out that would elevate the assessment of the course beyond the anecdotal level. The author concludes that the course would have been improved by providing more structure and feedback, maintaining a better balance between individual and group work, and doing more to promote individual accountability (e.g., give more individual tests) and positive interdependence (e.g., establish and rotate assigned roles within teams).

A better example of cooperative learning implementation and assessment is provided by Tien, Roth & Kampmeier (2002), who conducted peer-led team learning in a first-semester organic chemistry course over a three-year period and compared the achievement of the students with the that of students who had taken a traditional version of the course in the preceding three years. The course instructor, text, examination structure, and grading system were the same for both the treatment and comparison groups. While instruction in teamwork skills is not necessarily a component of PLTL, in this case the peer leaders were trained in group dynamics and group skills and used their training to help the student teams learn to function effectively. It is therefore fair to say that the PLTL implementation described in this study fully qualifies as cooperative learning. On average, the workshop students significantly outscored their traditionally taught counterparts on individual course exams, final course grades, retention in the course, and percentage earning the minimum acceptable grade of C– for moving on to the second semester organic chemistry course. Similar results were obtained specifically for female students and underrepresented minority students. The treatment group found the workshops and workshop problems their most important aids to learning in the course. Similar findings have been reported for PLTL programs in an organic chemistry class at another institution (Wamser, 2006) and in a biology course (Pederson, 1994), as well as for a cooperative learning implementation in organic chemistry (Dougherty, 1997).

A classical implementation of cooperative learning in chemistry is that of Hanson & Wolfskill (2000), who used a "process workshop" format in the general chemistry class at SUNY-Stony Brook. Students worked in teams of three or four on activities that involved guided discovery, critical thinking questions that help provide the guidance, solving context-rich and sometimes open-ended and incompletely defined problems, and metacognitive reflecting. Most activities focused on a single concept or issue and could be completed in a 55-minute session. Following each workshop, students completed an individual quiz on the workshop content, thus promoting individual accountability. The use of this approach led to substantially improved examination grades relative to the previous year, in which the course was conventionally taught, as well as increased attendance at recitation and tutorial sessions and improvements in student self confidence, interest in chemistry, and attitudes toward instruction. The same authors report on an interactive computer-assisted learning model that supports and enhances the process workshop format by providing immediate feedback on student efforts, networked reporting capabilities, and software tools for both peer assessment and self-assessment (Wolfskill & Hanson, 2001).

Empirical Studies on the Effects of Cooperative Learning Strategy on Students' Academic Achievement in Chemistry

This section reviewed related empirical studies on the effects of cooperative learning on students' achievement.

Ajaja (2013) investigated the effects of concept mapping, cooperative learning and learning cycle methods on biology students' achievement in Ika South Local Government Area of Delta State. The major purpose of this study was to compare the relative effectiveness of concept mapping, cooperative learning and learning cycle methods with the intention of identifying which one among them will be most appropriate for teaching biology. The sample of the study consisted of four mixed secondary schools, 259 students and eight biology teachers. The major findings of the study include: significant effect of the three instructional methods on achievement and retention; students in the learning cycle and cooperative leaning groups significantly out scored those in the concept mapping group on achievement and retention tests; students in learning cycle and cooperative learning groups did not significantly differ on achievement and retention tests; males and females in all the three groups did not significantly differ on the achievement test; and non significant interaction effect between sex and method of instruction on achievements. It was concluded that the adoption of either learning cycle or cooperative learning strategies will be appropriate for the teaching and learning of biology. The major distinction between this study and the current study is that this study compared three teaching methods with sex as moderating variable whereas this current study will compare one teaching method with sex and location as independent and moderating variable respectively.

In a study on cooperative learning, Gambari, James, and Olumorin (2013) investigated the effectiveness of video-based cooperative learning strategy on high, medium and low academic achievers. The design adopted for the study was retest, posttest, experimental control group design with four levels of independent variable (cooperative, competitive, individualistic and control groups) and three levels of achievement levels (high, medium and low) investigated on students' performance in Mathematics. The target population for the study was the second year senior secondary mathematics students in Minna, Nigeria and the sample size drawn using stratified random sampling technique were COOVIP (n = 30); experimental group two, COMVIP (n = 30); experimental group three, IVIP (n = 30); and control group, CVIP (n = 30). Equal numbers of high, medium and low students were equally selected from each group. The instruments for this research were the treatment instrument "Video Instructional Package (VIP)" and the test instrument, "Geometry Achievement Test (GAT)". The treatment instrument, Video Instructional Package (VIP) on Geometry, was a self-instructional, interactive package (contained buttons placed on the bottom of each page, such as Play, Stop, Pause, Next and Previous to provide easier control of the package) that lasted for 6 hours for an average student for six weeks. It contained six lesson topics on Angle at a point; Angles and Parallel lines; Angle properties of a triangle; Congruence and similarity of Triangles; Angles of a polygon; Parallelograms; Circles, Loci; and, Construction. The validation and evaluation of the package was done by mathematics experts, educational technology specialists for the appearance, operation, spelling, grammar, readability, and clarity from the viewpoint of persons unfamiliar with the content. The test instrument, Geometry Achievement Test (GAT) consisted of a 50-item multiple choice objective tests with five options (A – E) which were drawn from the past West African Examination Council (WAEC) Senior Secondary Certificate Examination.

The treatment procedure involved the students in the first experimental groups being exposed to video-based instruction, while the control group was taught using conventional teaching method. The treatment for all the groups lasted for six weeks. The GAT item was administered after the treatment and the data obtained was analyzed using Analysis of Variance (ANOVA) and Scheffe's test using Statistical Package for Social Sciences (SPSS) version 16 at 0.05 alpha level. The results indicated a significant difference in favour of the students taught with COOVIP and that those taught with COOVIP outperformed those taught using IVIP. It was recommended by the researchers that mathematics teachers should employ cooperative learning strategies to improve students' performance to bridge the gap among high, medium and low achievers. The findings of this study lent credence to the notion that cooperative learning bears some beneficial boost for learning science subjects. This underscored the need to further investigate the effect of cooperative learning and individualized instruction viz-a-viz conventional method of teaching on students' achievement in Chemistry.

In another study, Wayne (2013) examined the effects of cooperative Learning on the academic achievement, social interaction, behaviour, and effect on secondary school English and Social Studies students. The study was a three-chapter meta-analysis of the effects of different types of cooperative instructional approach on students' achievement, social interaction and behaviour of secondary level English and Social Studies students. The results indicated that Jigsaw II method yields higher academic achievement results than traditional whole-class instruction, and that the Jigsaw II method had a significant positive effect on academic achievement for ninth-grade students. Another finding on method of individual-plus-group accountability structure cooperative learning, also yielded significant positive effects on academic achievement. The findings focused on ability grouping, meaning that students in the cooperative treatments were deliberately grouped heterogeneously according to academic performance. It was found that students working in mixed-ability groups made fewer mistakes on in-class assignments and had a higher score on the posttest that they took as a group than students in the individual condition. However, when all students in the class took an individual posttest, there were no significant differences in achievement between students who worked individually and students who worked in groups. Several different studies examined a variety of mixed individual/group accountability structures, and the general conclusion is that the mixed accountability structures have a positive impact on academic achievement when students are grouped both randomly and heterogeneously. The researcher further reported that although the mixed accountability methods generally showed positive results on academic achievement, the fact that students are accountable for their own contributions in addition to the overall group contribution still leaves room for potential competition among group members. In all the study examined, the different cooperative learning approaches were found to have significant impact on students' achievement. This instigated the need to examine if cooperative learning will improve students' achievement in secondary school Chemistry concepts.

In a related study by Durukan's (2011) which employed the pre- and posttest quasi-experimental design to investigate the effects of Cooperative Integrated Reading and Composition (CIRC) on 24 seventh-grade Turkish students' academic achievement, it was found that the CIRC group had significantly higher reading and writing achievement scores than did the 21 control-group students taught via traditional whole-class instruction. In the study, students were randomly assigned to the control group and experimental group with a treatment that lasted for five weeks and the students working together two hours each week. The treatment procedure is as follows: in the first week of the treatment, students were assigned into four- to six-member mixed-ability groups and in the second week, groups prepared for their cooperative work by creating team names and slogans. In the third week, students were divided into pairs and given sentences to read. They were asked to read the sentences in pairs, correct them if necessary, and focus on pronunciation and stress patterns. Then students reconvened in their CIRC groups and were asked to answer two reading comprehension questions as a group. In the fourth week, students were asked to copy sentences written by the teacher to improve their writing skills. The groups then sent a copyist to the board to write down group answers. Groups were encouraged to critique each other's work. In the fifth week, students were asked 10 questions about the reading and writing activities they had completed, and the group with the most correct answers was given an achievement certificate. The instruments for data collection were a Written Expression Achievement Test (WEAT) and Reading Comprehension Achievement Test (RCAT), both developed by the researcher to collect data related to the study groups' writing skills and reading comprehension skills. The reliability indexes of the RCAT test was found to be 0.79 using the Kuder Richardson 20 (KR-20) formula, and the WEAT test was found to be 0.85 reliable also according to the KR-20 formula. The results of the study revealed a significant impact for both groups regarding the common effect of being in different student groups and different measurement periods, $F(2,86) = 25.216$, $p < 0.05$. Analysis of the WEAT scores yielded similar findings, $F(2,86) = 22.204$, $p < 0.05$. Although there were slightly higher arithmetical scores for the experimental group on both tests, the experimental CIRC method was more effective in increasing academic achievement. The study's demonstration of the effectiveness of CIRC, when compared to similar studies, strengthens the external validity of the method The vague description of the instructional procedures, as well as the fact that the control group also had significantly increased academic achievement throughout the study, calls into question the instrumentation and, hence, the internal validity of the research methods. Because both groups had statistically significant increases in reading comprehension and written expression, it is difficult to determine which factors of CIRC, if any, led to the slightly higher rates of achievement. Thus, there is need for further investigation and this underscored the need to further examine the effectiveness of cooperative method on students' achievement in Chemistry in secondary schools.

Cooperative learning study carried out by Şahin's (2010) experiment sought to uncover whether the Jigsaw II method would yield higher posttest and retention scores in Turkish pre-service teachers. The data for the academic achievement test was obtained by using Written Expression Achievement Test (WEAT) as instrument. The questions in the instrument were selected from a graduate school entrance examination and a government employment selection examination. To establish the reliability of the instrument, a pilot study was first carried out with 156 Turkish language teachers which led to the scaled-down test items consisting of 25 questions and was given to control and experimental groups as WEAT pretest, WEAT posttest, and WEAT retention-test. The procedure for experimentation involved dividing participants in the experimental Jigsaw treatment into six groups, and each member was responsible for taking on one expert writing task, such as correct punctuation or appropriate word usage. In the first week, the groups discussed how they would study their topics, and during the second week, they prepared study materials. In the third week, members met with their expert groups, and in the fourth week expert groups were given tests on their level of subject expertise. Because all of the expert groups had an achievement score over 90%, they returned back to their home groups in the fifth week and taught their own topics. In the sixth week, the topics were presented to other groups by a randomly chosen member from each group. The results were as follows: mean pre- and posttest scores of the control group ($n = 38$) were 14.76 ($SD = 2.10$) and 21.79 ($SD = 1.74$), $t = 14.940$, pre- and posttest scores for the experimental group ($n = 42$) were 14.59 ($SD = 2.24$) and 23.33 ($SD = 1.41$), $t = 23.498$. The t-scores show statistical significance between pre- and posttest scores for both groups ($p < 0.05$), but were higher for the experimental group. The Jigsaw II group therefore had a higher improvement in academic achievement. The experimental group also had higher scores on the retention test administered five weeks later. The score for the control group ($n = 38$) was 18.71 ($SD = 1.83$), and the score for the experimental Jigsaw II group ($n =42$) was 20.47, $t = 4.916$ at $p <0.05$. These findings suggest that Jigsaw II is more effective for learning and retention than traditional teacher-centered instruction. However, because the participants in the experiment designed their own study materials, it is difficult to say how they compared to the control group materials. Little information is given for either. This doubtful validity of the findings of the study instigated the need to investigate more the effect of cooperative learning style as this current study sets out to accomplish.

In Gocer's (2010) study on comparing the effectiveness on academic achievement of the Jigsaw technique and conventional teaching methods, it was found that the experimental group's posttest scores increased significantly. The study used sixty (60) eleventh-grade students in Kayseri State High School in Turkey during the 2008-2009 academic year. The students were randomly divided into control and experimental groups and were given a pre-test. In the treatment, the experimental group was divided into six groups of five students each, which were taught via cooperative methods, and the control group was taught via traditional whole-class methods. In the cooperative groups, after students discussed what they already knew about the topic, each group sent a representative to meet with other representatives from the other groups. After these expert groups met, they sent the representatives back and Jigsaw groups were reformed. These groups were then assigned to produce a final version of their lesson product. After finalizing what they knew about the topic, students retook the genre questions list test to see if there were any gains in knowledge between the pre- and posttest. The instrument for the study was Genre question list. Results obtained from the genre questions list, were analysed using the Statistical Package for the Social Sciences (SPSS) version 11.0. The data showed that the control group's mean scores went from 57.3 to 56.4, and the experimental group's mean scores went from 58.8 to 68.6. The statistical variances were insignificant. The t-test score between pre- and posttest results of the research group was -10.373, indicating significance at the $p < 0.0001$ level. This significant increase in the achievement scores of the experimental subjects incited the need to examine if the cooperative approach can boost achievement in secondary school Chemistry achievement in Delta Central Senatorial District.

Ajaja and Eravwoke (2010) investigated the effect of cooperative learning strategy on junior secondary school achievement in Integrated Science. The purpose of the study was to determine how the adoption of cooperative learning as an instructional strategy for teaching Integrated Science influences students' achievement and attitude towards studies. The study also determined how moderating variables like sex and ability affect students' achievement in Integrated Science when cooperative learning is used as an instructional strategy. The design of the study was a 2x2x2x2 factorial, pre-test, post-test control group design. These included two instructional groups (cooperative and traditional classroom groups), sex (male and female), ability (high and low), and repeated testing (pre-test and post-test). The population of study was made up of 205 JS III students from where a sample of 120 students was randomly selected. The instruments used for the collection of data included: a Scholastic Ability Test in Integrated Science (SATIS), Students' Attitude Scale (SAS), and Integrated Science Achievement Test (ISAT). All the data collected were analyzed with analysis of co-variance statistic. The major findings of the study included: a significant higher achievement test scores of students in cooperative learning group than those in traditional classroom; a significant higher attitude scores of students in cooperative learning group than those in traditional classroom; a significant higher achievement test scores of all students of varying abilities in cooperative learning group than those in traditional classroom; a non-significant difference in achievement test scores between the male and female students in the cooperative learning group, and non significant interaction effect between sex and ability, sex and method, ability and method and among method, sex and ability on achievement. The distinction between this study and the current study is that this study adopted factorial design; and sex and ability level as moderating variable. However, in this current study, quasi-experimental design was adopted, sex is an independent variable and location, a moderating variable.

In a quasi-experimental, posttest-only study, Phuong-Mai, Terlouw, Pilot, and Elliott (2009) examine the effect of Cooperative learning (CL) that features a culturally appropriate pedagogy. They hypothesized that cooperative learning strategy emphasizing culturally appropriate leadership, reward allocation, and group composition while studying a variety of subjects would yield higher learning outcomes among Vietnamese high school students than a traditional cooperative learning scenario that did not take cultural characteristics into consideration. The treatment involved the division of students into four classes that comprised a total of 181 students aged 16-18. Students were volunteers and were paid a small sum for participating. Each class was randomly divided into two experimental settings. One group of students was given CL lessons designed to be more culturally appropriate to Vietnamese learners in that they had a formal leader and that group composition was based on friendship. The second experimental group was given the same content and lessons, but the groups had no formal leader and the group composition was based on mixed-ability grouping. In both treatment groups, students were given group grades, not individual grades. Although the results of the study indicate that the researchers' hypothesis was rejected, there are still implications relevant to this review of the literature. Firstly, it is a posttest only study, so the researchers never empirically demonstrated that the subjects in both groups were of similar ability levels before the treatments were applied and this calls for further investigation where pre-test can be used to gauge the effect of the treatment. Secondly, the differences between the two experimental groups are too numerous to determine which factors led to a difference in achievement. Because leadership structure and ability-grouping were different in both groups, it is unclear which variables led to the significant outcomes. This also makes it impossible to determine whether the independent variable had an effect, again making it impossible to evaluate the internal validity of the study. These two limitations of the study call for further examination of the study on cooperative learning with a different design.

In another cooperative learning study, Adeyemi (2008) conducted a non-randomized quasi-experimental investigation of the effects of an individual accountability method of cooperative learning, on social studies achievement among 150 Nigerian students aged 11-15. The experimental group of students was put into groups of five and presented with instructional packages containing instructions and content to complete a task. The control group was taught via conventional lecture. The treatment lasted four weeks, and students were taught for three periods of 35 minutes each week. The results of the study showed that students in the experimental cooperative learning condition showed greater improvement between the pre- and posttests. Analysis of the results which was done using the Duncan Multiple Range Comparison showed that students in the conventional setting had a mean score of 7.26 and students in the cooperative setting had a mean score of 11.2036. All scores were significant at $p < 0.05$. The instruments of measurement administered to the students all had a split-half reliability over 78%. Pre- and posttest means were not included, costing the study both internal validity and methodological objectivity. This instigates the need for further studies on the effect of cooperative method of learning and instruction on students' achievement in Chemistry.

Empirical Studies on the Effect of sex on Academic Achievement of Chemistry Students

Sex refers to the varied socially and culturally constructed roles, qualities behaviour and so on that is ascribed to women and men by different societies (UNICEF, 1990). Nzewi (2010) defines sex as a psychological term describing behaviour and attributes expected of individuals on the basis of being born either male or female. Keller (1991) says gender is a cultural construct developed by the society to distinguish the role, behaviour, mental and emotional characteristic between males and females. Sadiq (1996) says that sex is a physical distinction; gender is a social and cultural one. This implies that roles expectations of males and females are defined by societies and cultures.

Sex differentiation is an old and long controversial issue in education. Different opinion and view abound on the issue of sex and its effects on student achievement. There are two strong opposing schools of thought as regards to the effect of gender and achievement while some scholars and researchers e.g. Obikese (2007) and Okoro (2011) contend that male student achieve higher than their female counterpart in science. Such scholar includes Mayer (2014) who determined the effect of games on maths achievement, interest and retention on junior secondary students in Igbo – Etiti L.G.A. He purposely sampled two hundred and twenty one (221) junior secondary two (JS2) students by simple random sampling. The data collected were analyzed using mean, standard deviation and ANCOVA. The findings revealed that the male students benefited more than their female colleagues. This study is similar to the present study in experimental design and method of data analysis but differs from it in other areas.

The other schools of thought Maduabum (1995), Nzewi (2010), Okeke (2008), are of the view that females achieve as high as their male counterparts when given equal opportunities. Okoro (2011), studied the effect of interaction patterns on achievement and interest in biology among secondary school students, findings from this study indicated that male students achievement and interest score where significantly higher than that of their female counterparts exposed to three (3) interaction patterns (cooperative, competitive and individualistic pattern of learning). In contrary to the findings of Okoro (2011) and Obikese (2007), Maduabum (1995) conducted a research on the effectiveness of the expository and guided discovery on student achievement in biology. Quasi – experimental design was used in carrying out the study which involved 82 first year senior secondary school students (42 males and 40 females). Analysis of the result showed that there were no significant difference in the achievement of male and female exposed to the two groups of teaching method. This study is similar to the present one in experimental design but differs from it in other areas.

Some other researchers have conflicting views in their findings. Such findings favoured girls more than boys. For instance, Ali (1998) studying polya's problem solving strategies in senior secondary school student's achievement and interest in Enugu state sampled 320 students purposely. The data analyzed using mean, standard deviation and ANCOVA revealed that the females enjoyed the strategies more than their male counterparts. His recommendation urged the teachers to employ this polya's method in teaching Mathematics. From the reviewed studies, no such work had been done on gender influence on achievement of students in Foods and Nutrition so there is need for this study.

Umoh (2001) investigated the effect of games on the achievement and interest of junior secondary school student in Igbo grammar. The insight gained from this study is the finding that gender was a significant factor on student over all achievement in Igbo grammar. The females performed significantly higher than their male counterpart. This study is similar to the present one in experimental design and method of data analysis but differs from it in other areas.

Oluikpe (2004) carried out an experiment to examine the effect of English for academic purposes (EAP) method on the achievement of University of Nigeria Education student in expository writing. The study found out that gender was not a significant factory on student over all achievement in expository writing although the mean achievement score of female was slightly higher than that of their male counterpart.

Anyafulude (2013) investigated the effects of Problem-based and Discovery-based instructional strategies on students' Achievement in Chemistry in Agbani Education Zone of Enugu State. The research adopted a quasi-experimental pre-test, post-test, non-equivalent control group design involving two experimental and one control groups. The sample comprised 375 senior secondary class two Chemistry students from three intact classes randomly drawn from a clustered sample of three senior secondary schools in Agbani Education Zone. The classes were assigned randomly to experimental and control groups. Experimental groups were taught selected topic in Chemistry using problem-based and discovery-based strategies. Control groups were taught the same topic using expository method. Pre-test was administered to both groups before the commencement of the treatment. Treatment was administered for a period of 6 weeks after which a post-test was administered. Data was collected using two instruments, pre and post-achievement tests in Chemistry duly validated and a reliability co-efficient of .71 obtained using Kuder Richardson 20 (KR – 20) formular. Data were analyzed using mean and standard deviation to answer the research questions while analysis of Coveriance (ANCOVA) tested hypotheses at .05 significance level. It was revealed among others that problem-based strategy significantly enhanced female students' performance than male counterparts.

Empirical Studies on the Influence of School Location on academic achievement of Chemistry Students

School location is concerned with the area where a school is located; schools are located in different areas due to need or availability of land. School can be located in urban or rural areas in Nigeria (Okeke, 2000). The location of a school affects the provision and use of different facilities for teaching and learning.

Oluikpe (2004) investigated the conceptual development of the co-ordinate references system of Nigeria Igbo students. She used 192 boys and girls of age range 8-19 years from schools in Nsukka Local Government Area. They were individually tested on three piagetian type special tasks. The water line Task (Horizontal), the orange Tray Task (Horizontal) and the vertical Tasks as well as the picture – interpretation Task. The orange Tray Task and the picture Interpretations Task were newly designed and African in orientation. She obtained a very poor result with no group obtaining a 50% pass at any age/grade level in the three tasks. Sex differences were significant in favour of boys and for the two horizontal tasks. There was also a significant difference in achievement between the more familiar orange Tray Task and the less familiar water-line task. There were no significant differences between urban and rural subjects on any of the four tasks.

She concluded that achievement of rural subjects was not significantly difference from that of the urban subjects.

In the contrary, in his research entitled, “sex-role and community variability in test performance” MacGregore and Elliot (2002) concluded that school location had a moderating influence upon the performances of junior high school students in cognitive and non-cognitive instruments. Obioma (2004) studied the achievement of students in mathematics and revealed that there was no related location difference on the achievement of students. On the contrary, Obioma (2004) revised the result by showing that school location was significant beyond 0.001 in mathematics achievement of students.

In another study titled “Urban and Rural background of first year university students in relation to their academic performance”, Dale and Miller (1972) reported that students from city school made the best progress in their first year at the university than those from rural or village schools. At home front, the above observations were reinforced by research reports as well. For instance, Izuwa, (1974) compared the academic achievement of rural and urban primary six pupils in East Central State of Nigeria. He concluded that urban primary six pupils obtained more credit level than rural primary six pupils while there was no significant difference between the urban and rural pupils at pass level. This is why Borg and Gall (2007) stressed that although intelligence may be inherited, school achievement is apparently determined to a substantial degree by environment. This present study will either enforce or refute the areas of controversy since there are inconsistent research reports with respect to the influence of location on achievement in some subject areas.

Appraisal of Review of Related Literature

The reviewed literature on the effect of cooperative learning strategy on students' academic achievement is contrasting. Most of the studies however found significant effect of cooperative learning strategy on students' achievement. However, none of the studies to the researcher's knowledge have investigated the effect of cooperative learning strategy on chemistry students' achievement using the Kagan's cooperative learning model at the secondary school level in Delta Central Senatorial District of Delta State.

Furthermore, it was observed from the literature reviewed that sex and school location can affect achievement in chemistry. The issue on sex, school location and academic achievement in chemistry centers generally on the extent to which females and males, students in urban and rural schools perform differently in the subject. The issue of influence of sex, school location on students' achievement in chemistry is found to be largely contradictory in the literature reviewed. Therefore, it is imperative to carry out further studies to provide more empirical evidence on the influence of sex and school location on students' achievement in chemistry.

It is this gap that the current study filled by investigating the effects of cooperative learning strategy and sex on students' achievement in Delta Central Senatorial District of Delta State.

CHAPTER THREE

RESEARCH METHOD AND PROCEDURE

This chapter presents a description of the method and procedure used in the study. The chapter was organized under the following sub-headings; research design, population of the study, sample and sampling techniques, research instrument, validity of the instrument, reliability of the instrument, treatment procedure and method of data analysis.

Research Design

The study adopted non-equivalent pretest, posttest control group quasi-experimental design. The quasi – experimental design was used since the classes of students that were used had already been organized into intact classes to provide for stability and avoid disruption of class lessons and class arrangement. In support of this design Borg and Gall (2007) stated that it is a suitable alternative to experimental design when randomization is not used or applied. According to Ali (2006), quasi-experimental research design can only be used where the researcher cannot randomly sample and assign his subjects to groups. In this design, both the experimental and control groups were exposed to the same treatment, and learning environment. The only difference between the two groups is their learning format. The experimental group learned with cooperative learning format while the control group learned with lecture method format in separate schools. The effects of the methods were then compared. The design is presented in the table 1.

Table 1: Design Matrix

Group	Pre-test	Treatment	Post-test
Experimental	O_1	X_e	O_2
Control	O_3	X_c	O_4

Where,

O_1 = pretest of cooperative learning instructional strategy group

O_2 = post-test of cooperative learning instructional strategy group

O_3 = pretest of lecture group

O_4 = post-test of lecture group

X_e = treatment with cooperative learning strategy

X_c = treatment with lecture method

Population of the Study

The population of the study comprised all senior secondary two (SS11) chemistry students in Delta Central Senatorial District of Delta State. The total population of SSII chemistry students was 8946 comprising 4701 females and 4245 males (See Appendix F). The SSII students were used for the study because they have already been selected into specific disciplines and also they were available to be used at any point in time, since they were not preparing for any external examination.

Sample and Sampling Technique

Purposeful sampling technique was used to select eight mixed secondary school with chemistry laboratory, eight chemistry teachers and 363 chemistry students from urban and rural secondary schools in Delta Central Senatorial District of Delta State.

The selected schools for the study were purposely selected based on the following parameters; presence of well equipped chemistry laboratory, trained and experienced chemistry teachers and school must be mixed. To this end, all the single sex schools and schools without laboratories were isolated from the study.

The distribution of sampled schools by location is shown in Table 2.

Table 2: Distribution of Schools by Sex Location

Schools	Location	No of chemistry students		
		Female	Male	Total
Okpe Grammar School, Sapele	Urban	20	31	51
Ibada Secondary School, IbadabElume	Rural	23	27	50
Alegbon Secondary School, Effurun	Urban	29	20	49

Opete Secondary School, Opete	Rural	20	31	51
Oviorie Secondary School, Oviorie	Rural	17	23	40
Oyenke Secondary School, Oyenke	Rural	15	11	26
Agbarho Grammar School, Agbarho	Urban	29	11	40
Effurun-Otor Secondary School, Effurun-Otor	Urban	27	29	56
Total		180	183	363

Note: schools located in villages were classified as rural schools and those located in towns were classified as urban schools based on availability of social amenities and infrastructural facilities.

Research Instrument

Chemistry achievement test (CAT) drawn from a six weeks learning package in chemistry on:

(1) electronic structure and occurrence of sulphur;

(2) laboratory and industrial preparation of sulphur;

(3) physical and chemical properties of sulphur and uses of sulphur;

(4) preparation of H_2S;

(5) preparation of H_2SO_4;

(6) physical and chemical properties of H_2SO_4; and

(7) uses of H_2SO_4 (See Appendix A, B) was the instrument for data collection in this study.

Chemistry achievement test (CAT) consisted of 50 multiple choice test items constructed by the researcher and which were drawn from the six weeks learning objectives. The duration for treatment lasted for 6 weeks (See Appendix C).

Validity of the Instrument

The face validity of the chemistry achievement test (CAT) was ensured by expert judgment of a panel of three experts made up of one experienced Chemistry Teacher drawn from Dom Domigo senior secondary school in Warri South Local Government Area of Delta State, one Chemistry Science Educator from Delta State University and an expert in Measurement and Evaluation from Delta State University Abraka. They examined the face validity of the instrument by critically examining the clarity and appropriateness of the test items. Their corrections included: that the preliminary information on the CAT was not complete, another distracters for question 10 should be found since the answer to the question was so obvious, in question 9, options B and D should be replaced with metals that combine with sulphur. The panel finally concluded that that the learning package should be expanded from four weeks to 6 weeks. Thereafter, their corrections and suggestions were effected in the instrument. The panel's approval of the test items as being able to measure what it intended to measure led to the use of the instrument for the study.

The content validity of the instrument was done using a table of specification which ensured that the questions covered all contents in the six weeks learning package as shown in Table 3.

Table 3: Table of specification on Chemistry Achievement Test (CAT)

Content Area	**Sub units**	**Mental Skills**	
		Lower Order	**Higher Order**

		Knowledge (28%)	Comprehension (24%)	Application (8%)	Analysis (14%)	Synthesis (14%)	Evaluation (12%)	Total (100%)
Sulphur	Sulphur (S) (40%)	8	6		2	2	2	20
	Extraction of S(10%)	2	1		1	1		5
	Allotropes of S(20%)	1	3	2	1	2	1	10
Compounds of Sulphur	Sulphuric Acid (20%)	1	2	1	3	1	2	10
	Industrial preparation (6%)	1		1		1		3
	Uses (4%)	1				1		2
Total		14	12	4	7	7	6	50

Reliability of the Instrument

The reliability of the CAT was established using the Kuder-Richardson 21 formula method. The rationale behind this method is that it is appropriate for objective test items that are homogenous and dichotomously scored. The instrument was administered to 40 chemistry students in Dom Domigo secondary school in Warri South Local Government Area of Delta State who were outside of the area delimited for the study and the obtained data were tested for reliability using Kuder-Richardson 21 formula. On analysis, a reliability coefficient value of 0.77 was obtained (See Appendix D). It is a standard that an instrument with a reliability coefficient value of 0.70 and above is reliable (Johnson & Christensen, 2000).

Treatment Procedure

A. Training of Research Assistants for Both Experimental and Control Group

Four out of the eight research assistants (teachers from the sampled schools) that were used for the study were trained by the researcher and two chemistry teachers on how to implement the Kagan's cooperative learning model with the use of structures. The training lasted for three days.

On the first day, the research assistants were exposed to the principles of Kagan's cooperative learning model involving the use of structures. Also, students' past academic achievement result were given to them and the grading categories to serve as the basis for organizing students into heterogeneous group within the lesson after the introduction and development of the lesson.

They were also exposed to how to supervise students' engagement within the group and conduct formative assessment which they used as basis to form homogeneous grouping of students with 0-4 grades and 5-10 grades. Students who fell into 0-4 grades were given extra attention while those within 5-10 grades were given enrichment activities. There after the class was re-organized into a whole to provide summary and closure of the lesson.

The second and third day were used for actual practice of the implementation of the learning model and possible problems and solution arising from the lesson.

The control group research assistants were not given training because they were used to the use of lecture method. Only the pre-prepared lesson note was given to ensure that the experimental and control groups were exposed to the same treatment.

B. Actual Treatment

Four intact SSII classes from the eight selected schools for the study were randomly selected comprising two schools from the urban and rural areas respectively to make up the cooperative learning group (experimental group). The four remaining intact SSII classes from the schools left comprising two schools from urban and rural locations each served as lecture method group (control group). Both the experimental and control groups were exposed to the same chemistry subject matter for six weeks.

Two days before the commencement of treatment, the experimental and control groups were pre-tested with the aid of the chemistry achievement test (CAT). This was done to determine the equivalence of the groups before treatment and be sure that any noticed change later was due to the treatment. At the end of the six weeks lesson, both the experimental and control groups were presented with posttest with the CAT (chemistry achievement test).

Method of Data Analysis

All the research questions were answered using mean and standard deviation. Hypotheses 1 was tested for significance using analysis of variance (ANOVA) since there was no significant difference in the experimental and control groups pre-test scores. Hypotheses 2, 3, 4, 5 and 6 were tested for significance using independent sample t-test since data from independent samples were compared. Hypotheses 7, 8 and 9 were tested for significance using analysis of covariance (ANCOVA) in order to incorporate both pre-test and posttest scores. All the hypotheses testing were done at 0.05 level of significance.

CHAPTER FOUR

PRESENTATION OF RESULTS AND DISCUSSION

This chapter presents the analysis of the data gathered from the pre-test and posttest through the chemistry achievement test (CAT).

Presentation of Results

The results of the analysis are presented in tables followed immediately with the interpretation of the results after each table. The results of the data analysis are presented in accordance with the research questions and hypotheses that guided the study.

Research Question 1

Is there any difference between the mean achievement scores of students taught chemistry with co-operative learning strategy and those taught with lecture method?

Table 4: Mean and standard deviation of pre-test and posttest achievement scores of students taught chemistry using cooperative learning instructional strategy and those taught with lecture method

Method	N	Pre-Test		Posttest		Mean	Mean Gain
		Mean	SD	Mean	SD	Gain	Difference
Cooperative Learning	201	22.13	9.49	58.59	12.50	36.46	9.71
Lecture	162	20.65	8.95	47.40	11.92	26.75	

The data in table 4 shows that the two groups were originally almost at the same level of achievement with a pretest mean achievement scores of 22.13, and standard deviation of 9.49, for cooperative learning instructional strategy (experimental group) and a pretest mean achievement score of 20.65, and standard deviation of 8.95, for the lecture method (control group). This implies that all the members in the experimental and control groups were almost equivalent on the knowledge of the concepts taught before treatment by mere comparison of the means. For the posttest, the experimental group obtained a higher mean score of 58.59, with a standard deviation of 12.50, for cooperative learning instructional strategy. The control group (lecture method) obtained a mean achievement score of 47.40, with a standard deviation of 11.92. The cooperative learning group had a mean gain score of 36.46, and the lecture method group had a mean gain score of 26.75. The difference in the mean gain scores of both groups is 9.71, in favour of the cooperative learning group. The cooperative learning instructional strategy group scored higher marks than the lecture method group.

Hypothesis 1 (H_{o1})

There is no significant difference between the mean achievement scores of students taught chemistry with co-operative learning strategy and those taught with lecture method.

Table 5: ANOVA summary of pre-test scores of cooperative learning instructional strategy (experimental) and lecture (control) groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	195.167	1	195.167	2.278	.132
Within Groups	30927.279	361	85.671		
Total	31122.446	362			

The ANOVA comparison of the groups as shown in Table 5 indicated non-significant difference, F (1, 361) = 2.278, P(0.132) > 0.05. This implies that there is no significant difference in the pre-test scores of the two groups compared. Hence, ANOVA was used to test hypothesis 1.

Table 6: ANOVA summary of post-test scores of cooperative learning instructional strategy (experimental) and lecture (control) groups

	Sum of Squares	df	Mean Square	F	Sig.	Decision
Between Groups	11236.216	1	11236.216	74.961	.000	H_{o1} rejected
Within Groups	54111.442	361	149.893			
Total	65347.658	362				

A significant difference was found between the group taught with cooperative learning instructional strategy and lecture method as shown in Table 6, F (1, 361) = 74.961, P(0.000) < 0.05. Therefore the null hypothesis is rejected. Thus, there is a significant difference between the mean achievement scores of students taught chemistry using cooperative learning instructional strategy and lecture method, in favour of cooperative learning instructional strategy.

Research Question 2

Is there any difference between the mean achievement scores of female students taught chemistry with co-operative learning strategy and those taught with lecture method?

Table 7: Mean and standard deviation of pre-test and posttest achievement scores of female students taught chemistry with cooperative learning instructional strategy and those taught with lecture method

Method	N	Pre-Test		Posttest		Mean	Mean Gain
		Mean	SD	Mean	SD	Gain	Difference
Cooperative Learning	92	21.96	9.80	57.22	11.90	35.26	9.55
Lecture	88	20.27	9.21	45.98	12.83	25.71	

Table 7 shows a pre-test mean achievement score of 21.96, with a standard deviation of 9.80, for female students taught chemistry with cooperative learning instructional strategy while female students taught chemistry with lecture method had a pretest mean achievement score of 20.27, with a standard deviation of 9.21. This implies that the female students in two groups were originally not at the same level of achievement. On the posttest scores, Table 7 indicated that the female students in the cooperative learning instructional strategy group had a mean achievement score of 57.22, with a standard deviation of 11.90, while the female students in the lecture group had a mean achievement score of 45.98, with a standard deviation of 12.83. The female students in the cooperative learning instructional strategy group had a mean gain of 35.26 as compare to female students in the lecture group with a mean gain of 25.71. The difference in the mean gain scores of both groups is 9.55, in favour of the female students in the cooperative learning instructional strategy group. The female students taught chemistry with cooperative learning instructional strategy scored higher marks than their counterparts taught with lecture method.

Hypothesis 2 (Ho_2)

There is no significant difference between the mean achievement scores of female students taught chemistry with co-operative learning strategy and those taught with lecture method.

Table 8: Summary of independent sample t-test comparison of posttest mean achievement scores of female students taught chemistry with cooperative learning instructional strategy and lecture method

Method	N	$\bar{x}$	SD	DF	t-cal	Sig. (2-tailed)	Decision
Cooperative	92	57.22	11.90				
				178	6.098	0.000	Ho_2 rejected
Lecture	88	45.98	12.83				

Table 8 shows that there was a significant difference in the mean achievement scores between female students taught chemistry with cooperative learning instructional strategy and lecture method, $t = 6.098$, $P(0.000) < 0.05$. Thus, the null hypothesis is rejected. Therefore, there is a significant difference between the mean achievement scores of female students taught chemistry with cooperative learning instructional strategy and lecture method, in favour of female students taught with cooperative learning instructional strategy.

Research Question 3

Is there any difference between the mean achievement scores of male students taught chemistry with cooperative learning strategy and those taught with lecture method?

Table 9: Mean and standard deviation of pre-test and posttest achievement scores of male students taught chemistry with cooperative learning instructional strategy and those taught with lecture method

Method	N	Pre-Test		Posttest		Mean	Mean Gain
		Mean	SD	Mean	SD	Gain	Difference
Cooperative Learning	109	22.28	9.27	59.74	12.93	37.46	9.66
Lecture	74	21.28	8.68	49.08	10.57	27.80	

Table 9 shows a pre-test mean achievement score of 22.28, with a standard deviation of 9.27, for male students taught chemistry with cooperative learning instructional strategy while male students taught chemistry with lecture method had a pre-test mean achievement score of 21.28, with a standard deviation of 8.68. This implies that the male students in two groups were originally not at the same level of achievement. On the posttest scores, Table 9 indicated that the male students in the cooperative learning instructional strategy group had a mean achievement score of 59.74, with a standard deviation of 12.93, while the male students in the lecture group had a mean achievement score of 49.08, with a standard deviation of 10.57. The male students in the cooperative learning instructional strategy group had a mean gain of 37.46, as compare to male students in the lecture group with a mean gain of 27.80. The difference in the mean gain scores of both groups is 9.66, in favour of male students in the cooperative learning instructional strategy group. The male students taught chemistry with cooperative learning instructional strategy achieved higher scores than those taught chemistry with the lecture method.

Hypothesis 3 (H_{o3})

There is no significant difference between the mean achievement scores of male students taught chemistry with co-operative learning strategy and those taught with lecture method.

Table 10: Summary of independent sample t-test comparison of posttest mean achievement scores of male students taught chemistry with cooperative learning instructional strategy and lecture method

Method	N	$\bar{x}$	SD	DF	t-cal	Sig. (2-tailed)	Decision
Cooperative	109	59.74	12.93				
				181	5.883	0.000	H_{o3} rejected
Lecture	74	49.08	10.57				

Table 10 shows that there was a significant difference in the mean achievement scores between male students taught chemistry with cooperative learning instructional strategy and lecture method, t = 5.883, P(0.000) < 0.05. Thus, the null hypothesis is rejected. Therefore, there is a significant difference between the mean achievement scores of male students taught chemistry with cooperative learning instructional strategy and lecture method, in favour of male students taught with cooperative learning instructional strategy.

Research Question 4

Is there any difference between the mean achievement scores of students in urban and rural schools taught chemistry using co-operative learning strategy?

Table 11: Mean and standard deviation of pre-test and posttest achievement scores of students in urban and rural schools taught chemistry using cooperative learning instructional strategy

Location	N	Pre-Test		Posttest		Mean	Mean Gain
		Mean	SD	Mean	SD	Gain	Difference
Urban	100	22.04	9.64	60.44	13.03	38.40	3.87

Rural	101	22.22	9.39	56.75	11.73	34.53

Table 11 shows a pretest mean achievement score of 22.04, with a standard deviation of 9.64, for urban students while rural students had a pre-test mean achievement score of 22.22, with a standard deviation of 9.39. This implies that the two groups were originally at the same level of achievement. On the posttest scores, Table 11 indicated that the urban students had mean achievement score of 60.44, with a standard deviation of 13.03, while the rural students had a mean achievement score of 56.75 with a standard deviation of 11.73. The urban students had a mean gain of 34.40 while the rural students had a mean gain of 34.53. Therefore, urban students performed better than rural students in chemistry when taught using cooperative learning instructional strategy.

Hypothesis 4 (H_{o4})

There is no significant difference between the mean achievement scores of students in urban and rural schools taught chemistry using co-operative learning strategy.

Table 12: Summary of independent sample t-test comparison of posttest mean achievement scores of students taught chemistry in urban and rural schools using cooperative learning instructional strategy

Location	N	$\bar{x}$	SD	DF	t-cal.	Sig. (2-tailed)	Decision
Urban	100	60.44	13.15				
				199	2.007	0.046	H_{o4} rejected
Rural	101	56.75	11.73				

Table 12 shows that there was a significant difference in the mean achievement scores between students taught chemistry in urban and rural schools using cooperative learning instructional strategy, t = 2.007, P(0.046) < 0.05. Thus, the null hypothesis is rejected. Therefore, there is a significant difference between the mean achievement scores of students taught chemistry in urban and rural schools using cooperative learning strategy, in favour of students in urban schools.

Research Question 5

Is there any difference between the mean achievement scores of male and female students in urban school taught chemistry using co-operative learning strategy?

Table 13: Mean and standard deviation of pre-test and posttest achievement scores of male and female students in urban school taught chemistry using cooperative learning instructional strategy

Gender	N	Pretest		Posttest		Mean Gain	Mean Gain Difference
		Mean	SD	Mean	SD		
Male	51	23.45	8.86	62.75	13.99	39.30	1.83
Female	49	20.57	10.29	58.04	11.61	37.47	

In Table 13, the male posttest mean score is 62.75, with a pre-test mean score of 23.45 and mean gain of 39.30 and the females had a posttest score of 58.04, with pretest mean score of 20.57 and mean gain of 37.47 when exposed to cooperative learning instructional strategy. The overall mean gain difference between the two groups is 1.83, in favour of male students in urban school taught chemistry using cooperative learning instructional strategy. This showed that the male students in urban school achieved higher in chemistry than their female counterparts.

Hypothesis 5 (H_{o5})

There is no significant difference between the mean achievement scores of male and female students in urban school taught chemistry using co-operative learning strategy.

Table 14: Summary of independent sample t-test comparison of posttest mean achievement scores of male and female students in urban school taught chemistry using cooperative learning instructional strategy

Gender	N	$\bar{x}$	SD	DF	t-cal.	Sig. (2-tailed)	Decision
Male	51	62.71	13.99	98	0.141	0.888	H_{o5} accepted
Female	49	58.04	11.61				

Table 14 shows that there was no significant difference between the mean achievement scores of male and female students in urban school taught chemistry using cooperative learning instructional strategy, t = 0.141, P(0.888) > 0.05. Thus, the null hypothesis is retained. This implies that there is no significant difference between the mean achievement scores of male and female students in urban school taught chemistry using cooperative learning instructional strategy.

Research Question 6

Is there any difference between the mean achievement scores of male and female students in rural school taught chemistry using co-operative learning strategy?

Table 15: Mean and standard deviation of pre-test and posttest achievement scores of male and female students in rural school taught chemistry using cooperative learning instructional strategy

Gender	N	Pretest		Posttest		Mean Gain	Mean Gain Difference
		Mean	SD	Mean	SD		
Male	58	21.24	9.57	57.10	11.40	35.86	3.11
Female	43	23.53	9.08	56.28	12.29	32.75	

In table 15, the male posttest mean score is 57.10, with a pre-test mean score of 21.24 and mean gain of 35.86, and the female had a posttest score of 56.28, with pretest mean score of 23.53 and mean gain of 32.75, when exposed to cooperative learning instructional strategy. The overall mean gain difference between the two groups is 3.11, in favour of male students in rural school taught chemistry using cooperative learning instructional strategy. This showed that the male students taught chemistry using cooperative learning strategy in rural school achieved higher scores in chemistry than their female counterparts.

Hypothesis 6 (H_{o6})

There is no significant difference between the mean achievement scores of male and female students in rural school taught chemistry using co-operative learning strategy.

Table 16: Summary of independent sample t-test comparison of posttest mean achievement scores of male and female students in rural school taught chemistry using cooperative learning instructional strategy

Gender	N	$\bar{x}$	SD	DF	t-cal.	Sig. (2-tailed)	Decision
Male	58	57.10	11.40				
				99	0.921	0.359	H_{o6} accepted
Female	43	56.28	12.29				

Table 16 shows that there was no significant difference between the mean achievement scores of male and female students in rural school taught chemistry using cooperative learning instructional strategy, $t = 0.921$, $P(0.359) > 0.05$. The null hypothesis is retained. This implies that there is no significant difference between the mean achievement scores of male and female students in rural school taught chemistry using cooperative learning instructional strategy.

Research Question 7

Is there any effect of interaction of sex and teaching methods on students' achievement in chemistry?

Table 17: Mean and standard deviation on effect of interaction of sex and teaching methods on chemistry achievement

Methods		Cooperative Learning			Lecture	
	N	Mean	SD	N	Mean	SD
Pretest						
Male	109	22.28	9.27	74	21.11	8.68
Female	92	21.96	9.80	88	20.27	9.20
Differences		**0.32**	**-0.53**		**0.84**	**-0.52**
Posttest						
Male	109	59.74	12.93	74	49.08	10.57
Female	92	57.22	11.90	88	45.98	12.83
Differences		**2.52**	**1.03**		**3.10**	**-2.26**

Table 17 shows a mean achievement score of 59.74, for male students who were taught with cooperative learning instructional strategy (experimental group), while their female counterparts had a mean achievement scores of 57.22. Male students who were taught with lecture method (control) had a mean achievement score of 49.08, while their female counterparts had a mean achievement score of 45.98. The results do not suggest ordinal interaction effect between teaching methods and sex on students' achievement in chemistry. This was because at all the levels of sex, the mean achievement scores were higher for students in the cooperative learning instructional strategy (experimental) group.

Hypothesis 7 (H_{o7})

There is no significant effect of interaction of sex and teaching methods on students' achievement in chemistry.

Table 18: ANCOVA summary on effect of interaction of and teaching methods on chemistry achievement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25035.195[a]	4	6258.799	55.582	.000
Intercept	86561.142	1	86561.142	768.717	.000
Pretest	13093.464	1	13093.464	116.278	.000
Methods	8893.595	1	8893.595	78.981	.000
Sex	529.243	1	529.243	4.700	.031
methods * sex	1.300	1	1.300	.012	.914
Error	40312.463	358	112.605		
Total	1107932.000	363			
Corrected Total	65347.658	362			

Table 18 shows that there was no significant effect of interaction of sex and teaching methods as measured by the students' mean achievement scores in chemistry, $F(1, 358) = 0.012$, $P(0.914) > 0.05$. Therefore, the null hypothesis is retained. Thus, there is no significant effect of interaction of sex and teaching methods as measured by the mean achievement scores in Chemistry Achievement Test (CAT). This implies that the students' achievement scores relative to the teaching methods is not influenced by sex.

Research Question 8

Is there any effect of interaction of school location and teaching methods on students' achievement in chemistry?

Table 19: Mean and standard deviation on effect of interaction of school location and teaching methods on students' achievement in chemistry

Methods		**Cooperative Learning**			**Lecture**	
	N	**Mean**	**SD**	**N**	**Mean**	**SD**
Pretest						
Urban	100	22.04	9.64	96	20.50	8.43
Rural	101	22.22	9.39	66	20.88	9.72
Differences		**-0.18**	**0.25**		**-0.38**	**-1.29**
Posttest						
Urban	100	60.44	13.03	96	48.65	10.70
Rural	101	56.75	11.73	66	45.58	13.38
Differences		**3.69**	**1.30**		**3.07**	**-2.68**

Table 19 shows a mean achievement score of 60.44, for urban students who were taught with cooperative learning instructional strategy (experimental group), while their rural counterparts had a mean achievement scores of 56.75. Urban students who were taught with lecture method had a mean achievement score of 48.65, while their rural counterparts had a mean achievement score of 45.58. The results do not suggest ordinal interaction effect between teaching methods and school location on students' achievement in chemistry. This was because at all the levels of school location, the mean achievement scores were higher for students in the experimental group.

Hypothesis 8 (H_{o8})

There is no significant effect of interaction of school location and teaching methods on students' achievement in chemistry.

Table 20: ANCOVA Summary of interaction effect between school location and teaching methods on chemistry achievement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25662.093[a]	4	6415.523	57.874	.000
Intercept	85101.573	1	85101.573	767.694	.000
Pretest	13373.966	1	13373.966	120.645	.000
methods	9713.260	1	9713.260	87.622	.000
location	1115.821	1	1115.821	10.066	.002
methods * location	5.179	1	5.179	.047	.829
Error	39685.565	358	110.854		
Total	1107932.000	363			
Corrected Total	65347.658	362			

Table 20 shows that there was no significant interaction effect between teaching methods and school location as measured by the students' mean achievement scores, $F(1, 358) = 0.047$, $P(0.829) > 0.05$. Therefore, the null hypothesis is retained. Thus, there is no significant effect of interaction of teaching methods and school locations as measured by the students' mean achievement scores in Chemistry Achievement Test (CAT).

Research Question 9

Is there any effect of interaction of sex, school location and teaching methods on students' achievement in chemistry?

Table 21: Mean and standard deviation on effect of interaction of sex, school location and teaching methods on chemistry achievement

Methods		**Cooperative Learning**			**Lecture**	
	N	**Mean**	**SD**	**N**	**Mean**	**SD**
Pretest						
Male	109	22.28	9.27	74	21.11	8.68
Female	92	21.96	9.80	88	20.27	9.20
Differences		**0.32**	**-0.53**		**0.84**	**-0.52**
Urban	100	22.04	9.64	96	20.50	8.43
Rural	101	22.22	9.39	66	20.88	9.72
Differences		**-0.18**	**0.25**		**-0.38**	**-1.29**
Posttest						
Male	109	59.74	12.93	74	49.08	10.57
Female	92	57.22	11.90	88	45.98	12.83
Differences		**2.52**	**1.03**		**3.10**	**-2.26**
Urban	100	60.44	13.03	96	48.65	10.70

Rural	101	56.75	11.73	66	45.58	13.38
Differences		**3.69**	**1.30**		**3.07**	**-2.68**

Table 21 shows a mean achievement score of 59.74, for male students taught chemistry using cooperative learning instructional strategy (experimental group), while their female counterparts had a mean achievement scores of 57.22. Male students who were taught with lecture method had a mean achievement score of 49.08, while their female counterparts had a mean achievement score of 45.98.

Table 21 also shows a mean achievement score of 60.44, for urban students who were taught with cooperative learning instructional strategy (experimental group), while their rural counterparts had a mean achievement score of 56.75. Urban students who were taught with lecture method had a mean achievement score of 48.65, while their rural counterparts had a mean achievement score of 45.58. The results do not suggest ordinal interaction effect among teaching methods, sex and school location on students' achievement in chemistry. This was because at all the levels of sex and school location, the mean achievement scores were higher for students in the experimental group.

Hypothesis 9 (H_{o9})

There is no significant effect of interaction of sex, school location and teaching methods on students' achievement in chemistry.

Table 22: ANCOVA Summary of interaction effect sex, school location and teaching methods on chemistry achievement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26374.336[a]	8	3296.792	29.945	.000
Intercept	83616.122	1	83616.122	759.497	.000
Pretest	12451.873	1	12451.873	113.102	.000

Methods	9333.449	1	9333.449	84.777	.000
Location	1218.901	1	1218.901	11.071	.001
Sex	697.367	1	697.367	6.334	.012
methods * location	5.179	1	5.179	.047	.829
methods * sex	1.300	1	1.300	.012	.914
location * sex	14.634	1	14.634	.133	.716
methods * location * sex	38.720	1	38.720	.352	.554
Error	38973.322	354	110.094		
Total	1107932.000	363			
Corrected Total	65347.658	362			

Table 22 shows that there was no significant effect of interaction of teaching methods, sex and school location as measured by the students' mean achievement scores, $F(1, 354) = 0.352$, $P(0.554) > 0.05$. Therefore, the null hypothesis is retained. Thus, there is no significant effect of interaction among sex, school location and teaching methods as measured by the students' mean achievement scores in Chemistry Achievement Test (CAT). This implies that the students' scores relative to the teaching methods was not influenced by gender or location, or a combination effect of gender and location.

Discussion of Results

The first result of the study as shown in Table 3 indicated that students taught chemistry with cooperative learning instructional strategy (experimental group) performed better than those taught with lecture method (control group). The differences in achievement scores among the groups may be attributed to the variation in the method of instruction adopted in each of the group. These may again have translated into influencing students' scores in the achievement test. The fact that students taught chemistry with cooperative learning instructional strategy outscored those taught with lecture method suggests that the students in the experimental group may have been more active in the learning process than those in the lecture group and thus have contributed to their higher achievement scores. This is hinged on the fact that you learn better by doing (Ajaja, 2013). The low achievement scores as found among the students taught with lecture method may be connected with the transmission approach involved, where the teachers provide students with needed knowledge. Bennett (2003) noted that the transmission view implies that pupil's role in the learning process is largely passive, and that a pupil's mind is what is some-times called a "tabula rasa".

The significant higher achievement of students taught with cooperative learning instructional strategy over those taught with lecture method as found in this study corroborates the findings of Ajaja and Eravwoke (2010); and Igboanugo (2013) who reported that cooperative learning instructional strategy is more efficacious in capturing students' interest as well as improving their academic achievement than the lecture method.

The second result of the study showed that there is a significant difference between the mean achievement scores of female students taught chemistry with cooperative learning instructional strategy and lecture. The female students in the cooperative learning instructional strategy (experimental) group outscored their counterparts in the lecture (control) group. This may be attributed to the fact that there was active involvement and interaction among students, between students and teachers, between students and learning environment in the experimental group. This may have boosted the mean achievement scores of the female students in the experimental group because there is internal satisfaction derived from self discovery of knowledge. This finding is in consistence with the finding of Nnorom (2015) who observed that cooperative learning instructional strategy was more effective in facilitating students' conceptualization of science concepts than the lecture method.

The third result of the study showed that there is a significant difference between the mean achievement scores of male students taught chemistry with cooperative learning instructional strategy and lecture method in favour of male students in the cooperative learning instructional strategy group. The possible explanation for this finding is the same as the second finding of this study. This finding is in line with the view of Nnorom (2015) who reported the superiority of the cooperative learning instructional strategy over lecture method in enhancing students' achievement in science subjects.

The fourth result of the study showed that there is a significant difference between the mean achievement scores of students taught chemistry in urban and rural schools using cooperative learning strategy. Students in urban school taught chemistry using cooperative learning instructional strategy outperformed their rural counterparts taught with cooperative learning instructional strategy. The explanation for the observed significant difference in the mean achievement scores of students in urban and rural schools is that there is a gap that existed between the surrounding of rural schools which usually have inadequate human and material resources as compared to urban scores which have lot of fascinating and stimulating materials for teaching as well as larger number of teachers to teach. This finding contradicts the view of Mathew (2014) who observed a significant difference between the mean achievement scores of students in urban and rural schools taught chemistry with cooperative learning instructional strategy, in favour of the students in rural schools.

The fifth result of the study showed that there is no significant difference between the mean achievement scores of male and female students in urban school taught chemistry using cooperative learning instructional strategy. Cooperative learning instructional strategy enhanced the mean achievement scores of both male and female students in urban school. This is predicated on the fact that cooperative learning instructional strategy can easily be adopted in urban schools as a result of the presence of improved instructional facilities. Therefore, male and female students in urban schools had the opportunity of actively participating in the teaching and learning process discovering facts on their own. This finding corroborates with the view of Mathew (2014) who reported that cooperative learning instructional strategy effectively improve the academic achievement of male and female students in urban schools.

The sixth result of the study revealed that there is no significant difference between the mean achievement scores of male and female students in rural school taught chemistry using cooperative learning instructional strategy. The explanation for this observation is simply due to the fact that cooperative learning instructional strategy provides the opportunity for both male and female students in the rural schools be actively involved during the teaching and learning process. This finding is in line with the view of Ajaja and Eravwoke (2010) who reported effectiveness of cooperative learning instructional strategy in stimulating the interest of male and female students irrespective of their location.

The seventh result of the study revealed that there is no significant effect of interaction of sex and teaching methods as measured by the mean achievement scores in Chemistry Achievement Test (CAT). This finding is in line with that of Ajaja and

Eravwoke (2010) who reported a non-significant interaction effect between sex and teaching methods on students' achievement in integrated science.

The eight result of the study revealed that there is no significant effect of interaction of teaching methods and school locations as measured by the students' mean achievement scores in Chemistry Achievement Test (CAT). This finding is in contrast with that of Mathew (2014) who observed a significant interaction effect between school location and teaching methods on students' achievement in chemistry.

The ninth result of the study revealed that there is no significant effect of interaction effect among sex, school location and teaching methods as measured by the students' mean achievement scores in Chemistry Achievement Test (CAT). This finding is in contrast with that of Mathew (2014) who observed a significant interaction effect among sex, school location and teaching method.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMNDATIONS

Summary of the Study

The study focused on the effects of cooperative learning instructional strategy and sex on students' achievement in chemistry in Delta Central Senatorial District of Delta State. Nine research questions and nine hypotheses were raised and formulated respectively to guide the study. The design of the study was quasi-experimental design, specifically pre-test, posttest non-equivalent control group design. The instruments used in the study was chemistry achievement test (CAT) drawn from a six-week instructional units on sulphur and its compound constructed by the researcher which were validated by three experts: one Experienced Chemistry Teacher in a school in Warri South Local Government Area of Delta State, an expert in Measurement and Evaluation and one Chemistry Science Educator from the Department of Science Education, Faculty of Education, Delta State University, Abraka. The reliability of the CAT was established using the kuder-Richardson formula 21. This was done by administering the CAT to forty (40) chemistry students outside the area of the study and computing the reliability index. The reliability coefficient of the CAT was found to be 0.77.

The treatment involved exposing the students in the experimental group to the chemistry concept “sulphur and its compound” with the use of cooperative learning instructional strategy and the control group with lecture method. Pre-tests were administered before the treatment and posttest thereafter using the CAT. The scores obtained were collated and analyzed using descriptive statistics, independent sample t-test, analysis of variance (ANOVA) and analysis of covariance (ANCOVA).

Major Findings

Analysis of the result revealed the following findings:

1. There was a significant difference between the mean achievement scores of students taught chemistry using cooperative learning instructional strategy (experimental) and lecture method (control).
2. There was a significant difference between the mean achievement scores of male and female students taught chemistry with cooperative learning instructional strategy and lecture method.
3. There was a significant difference between the mean achievement scores of students taught chemistry in urban and rural schools using cooperative learning instructional strategy, in favour of students in urban school.
4. There was no significant difference between the mean achievement scores of male and female students in urban and rural schools taught chemistry using cooperative learning instructional strategy.
5. There was no significant effect of interaction of sex and teaching methods on achievement in chemistry as measured by the students mean achievement scores in chemistry achievement test.

6. There was no significant effect of interaction of school location and teaching methods as measured by the students’ mean achievement scores in chemistry achievement test.

7. There was no significant effect of interaction among sex, school location and teaching methods on achievement as measured by the students’ mean achievement scores..

Conclusion

The study concluded that cooperative learning strategy significantly improved students’ achievement in chemistry more than the lecture method. Also, cooperative learning strategy did not significantly differentiate between sexes and school location with respect to students’ achievement in chemistry. Finally, cooperative learning did not combine with sex and school location to influence students’ achievement in chemistry.

Recommendations

In the light of the findings of the study, the following recommendations are made to facilitate effective teaching and learning of chemistry.

1. Chemistry teachers should adopt the use of cooperative learning instructional strategy in the teaching of chemistry at the secondary school level. This instructional strategy may ensure students active involvement, self-discovery of knowledge, as well as giving students the opportunity to learn from other students concepts they could not learn on their own.

2. Special training on the effective implementation of cooperative learning instructional strategy should always be organized for teachers and students by the

government, so as to help them become competent in the use of this teaching strategy in the teaching and learning process.

3. Higher teacher training institution such as colleges of education and universities should train student-teachers on the effective implementation of cooperative learning` and other innovative instructional strategy.

4. Workshops and seminars should be organized for teachers by the government and stake holders in education to keep them abreast of cooperative learning instructional strategy and other innovative active teaching strategies to enhance easy implementation in classroom teaching.

Contributions to Knowledge

The study contributed to knowledge in the following ways.

1. The study established that cooperative learning instructional strategy significantly improve students' achievement in chemistry.

2. The study also established that the effect of cooperative learning instructional strategy is not location biased.

3. The study also confirmed that male and female chemistry students exposed to cooperative learning instructional strategy perform equally.

4. The study finally established that there is no significant interaction effect among sex, school location and teaching methods on students' achievement in chemistry.

Suggestions for Further Studies

The following are suggestions for further research:

1. A research should be carried out on the effect of cooperative learning instructional strategy on students' achievement in other discipline.

2. A research should be carried out on the effect of collaborative instructional strategy on students' achievement and retention in chemistry.

3. A research should be carried out on the effect of instructional scaffolding on students' achievement and interest in chemistry is.

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APPENDICES

APPENDIX A

LESSON NOTE ON COOPERATIVE LEARNING METHOD

WEEK 1

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^{+}

Mental Ability: Mixed

Topic: Sulphur and its compound (Occurrence and Extraction of Sulphur).

Entry Behaviour: Students can state the properties of P-block elements.

Instructional Objectives: At the end of the lesson, given the periodic table and a chart of sulphur students should be able to:

1. Describe the general properties of group VI element
2. Describe the electronic structure of sulphur
3. Describe the occurrence and extraction of sulphur by Frasch process

Instructional Materials: New school chemistry by Osei Yaw Ababio, chart of sulphur and its compounds and the periodic table

Instructional Procedure:

Step 1

- Teacher presents students with the instructional objectives
- Teacher inform students about the assessment of their own work and their peer
- Each students will be responsible for a task within the group
- Final mark will be part of group mark of 50% and part of individual task mark of 50% (100%)

Step 2

Teacher revised the previous lesson with the following questions:

1. Give 2 uses of any oxide of nitrogen
2. Give four uses of ammonia

Step 3

Teacher introduces and develops the lesson by explaining the position and extraction of sulphur.

Sulphur

Sulphur belongs to group 6 of the periodic table. The sulphur atom like all group six members has six valence electrons. In order to achieve an octect structure, it gains two electrons, usually from group 1 and 2 metals, to form a divalent sulphide ion, S^{2-}. With non-metals, sulphur attain octect structure by sharing electrons to form covalent compounds such as hydrogen sulphide, H-S-H. The oxidation state of sulphur can range from -2 to +6. Sulphur has been known for its medicinal and germicidal effect. It makes up about 0.1% of the earth's crust. It occurs freely as deposit in U.S.A, Poland, Japan, New Zealand and Sicily. It is widely found in the combined state as suphides of iron, zinc, lead, copper and mercury, and as tetraoxosulphate (VI) salts of calcium, magnesium and barium. Sulphur is also present in some proteins.

Extraction of Sulphur

The extraction of sulphur from its underground deposit of more than 200m below the earth's surface is based on the Frasch process. A hole about 30cm in diameter is drilled through the soil to the sulphur bed. A sulphur pipe made of three concentric pipes is then driven down the hole. Super-heated water of about 170^{o}C and 10 atm pressure is forced through the outermost tube to the sulphur bed to melt the sulphur. Hot compressed air at a pressure of 15 atm is then blown down the inmost tube to force the sulphur up through the middle tube. The molten sulphur is continually pumped into a receptacle at the surface where it is allowed to solidify in large tanks. The sulphur obtained is about 99.5% pure.

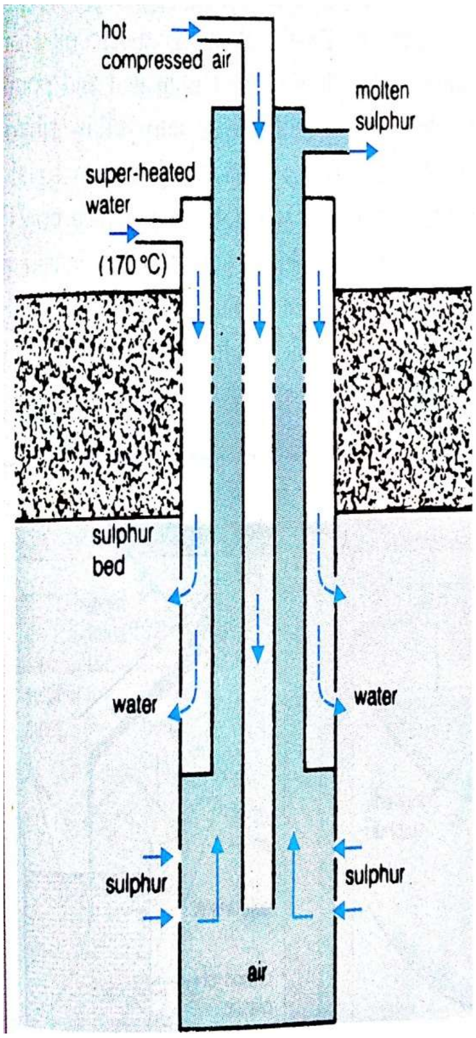

Fig. 1: Extraction of sulphur (Frasch process)

Step 4

Based on students passed academic records, students are shared into heterogeneous group in the lesson. Students are given the following activities to work in group.

Questions

1. Describe the general properties of group VI elements and electronic structure of sulphur
2. Describe the occurrence and extraction of Sulphur by frasch process

Fig. 2: Heterogeneous Grouping of students within the teaching-learning process

Step 5

Teacher moves round the group to see how the students are engaged in the learning task.

Step 6

Based on the feedback from students self assessment, peer assessment and teacher assessment (formative evaluation), students are grouped into homogeneous group so that students who need extra help can get more attention while those who do not need extra help are given something else to do to reinforce the lesson. The teacher give students in the homogeneous group the following task

Questions

1. Describe the general properties of group VI elements and electronic structure of sulphur
2. Describe the occurrence and extraction of Sulphur by frasch process

Fig. 3: Homogeneous Grouping of students within the teaching-learning process

Step 7

Based on teacher assessment feedback on the homogeneous group, the groups are rearranged into a whole class and the teacher summarizes the lesson and gives students summative evaluation.

Questions

1. Describe the general properties of group VI elements and electronic structure of sulphur
2. Describe the occurrence and extraction of Sulphur by frasch process

Step 8

Teacher gives the following assignment to the students

1. State five physical properties of sulphur
2. Describe three chemical properties of suphur

LESSON NOTE ON COOPERATIVE LEARNING METHOD

WEEK 2

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^+

Mental Ability: Mixed

Topic: Sulphur and its compound (Physical and Chemical Properties of Sulphur).

Entry Behaviour: Students can explain the occurrence and extraction of sulphur.

Instructional Objectives: At the end of the lesson, given the periodic table and a chart of sulphur students should be able to:

1. State five physical properties of sulphur
2. Describe three chemical properties of suphur

Instructional Materials: New school chemistry by Osei Yaw Ababio, sulphuric acid, water, litmus paper.

Instructional Procedure:

Step 1

Teacher presents students with the instructional objectives

- Teacher inform students about the assessment of their own work and their peer
- Each students will be responsible for a task within the group
- Final mark will be part of group mark of 50% and part of individual task mark of 50% (100%)

Step 2

Teacher revises the previous lesson with the following questions:

1. Describe the electronic structure of sulphur
2. Describe the occurrence and extraction of sulphur

Step 3

Teacher introduces and develops the lesson by explaining the physical and chemical properties of sulphur.

Physical properties of Sulphur

1. Sulpur is a yellow solid. It exists in two forms of amorphous and crystalline.
2. It is insoluble in water but in carbon (iv) sulphide and methyl benzene (toluene)
3. It is a bad conductor of heat and electricity.
4. Density depends on allotropic form.
5. It has a melting point of 119^{o}C and a boiling point of 444^{o}C.

Chemical properties of Sulphur

1. Direct combination with other elements:

With metals: sulphur combines directly with metals to form sulphides when heated in the absence of air.

$$Fe(s) + S(s) \rightarrow FeS(s)$$

With Oxygen: When sulphur is heated in plentiful supply of air, it burns with a brightly yellow flame to form sulphur (IV) oxide and a small amount of sulphur (VI) oxide.

$$O_2(g) + S(s) \rightarrow SO_2(g)$$

With Carbon: sulphur combines with coke in an electric furnance to form a colourless liquid known as carbon (IV) sulphide, which vapourizes readily, forming poisonous and highly flammable fumes.

$$C(s) + 2S(s) \rightarrow CS_2(l)$$

With other non-metals: sulphur combines with other non-metals to form various sulphides, e.g. tetraphosporus trisulphide, P_4S_3, disulphide dichloride, S_2Cl_2, and sulphur hexafluoride, SF_6.

1. **Action of oxidizing acids:** Sulphur is readily oxidized when warmed with concentrated tetraoxosulphate (VI) acid to form sulphur (VI) oxide.

$$2H_2SO_4(aq) + S(s) \rightarrow 2H_2O(l) + 3SO_2(g)$$

2. **Action of hot concentrated alkalis:** Sulphur will react with hot concentrated solution to form a mixture of sulphides and trioxosulphates (IV), which, in the presence of excess sulphur, react to form a polysulphide and a trioxothiosulphate (VI) respectively.

$$3S + 6OH^- \rightarrow SO_3^{2-} + 3H_2O$$

Step IV

Based on students passed academic records, students are shared into heterogeneous group in the lesson. Students are given the following activities to work in group.

Questions

1. List 5 physical properties of sulphur
2. List with equations three chemical properties of sulphur.

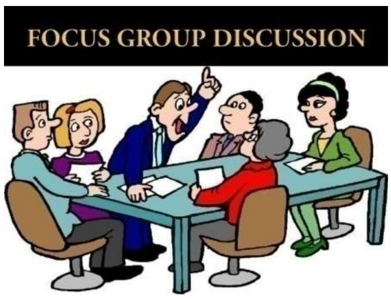

Fig. 4: Heterogeneous Grouping of students within the teaching-learning process

Step 5

Teacher moves round the group to see how the students are engaged in the learning task.

Step 6

Based on the feedback from students self assessment, peer assessment and teacher assessment (formative evaluation), students are grouped into homogeneous group so that students who need extra help can get more attention while those who do not need extra help are given something else to do to reinforce the lesson. Teacher give students in the homogeneous group the following task:

1. List 5 physical properties of sulphur
2. List with equations three chemical properties of sulphur.

Fig. 5: Homogeneous Grouping of students within the teaching-learning process

Step 7

Based on teacher assessment feedback on the homogeneous group, the groups are rearranged into a whole class and the teacher summarizes the lesson and gives students summative evaluation.

Questions

1. List 5 physical properties of sulphur
2. List with equations three chemical properties of sulphur

Step 8

Teacher gives the following assignment to the students

1. List and describe three allotropes of sulphur
2. Explain at least three uses of sulphur

LESSON NOTE ON COOPERATIVE LEARNING METHOD

WEEK 3

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^+

Mental Ability: Mixed

Topic: Sulphur and its compound (Allotropes and uses of sulphur).

Entry Behaviour: Students can explain the physical and chemical properties of sulphur.

Instructional Objectives: At the end of the lesson, given the periodic table and charts of sulphur students should be able to:

1. List and describe three allotropes of sulphur
2. Explain at least three uses of sulphur

Instructional Materials: New school chemistry by Osei Yaw Ababio, chart of sulphur allotropes, fungicides and insecticides made of sulphur compounds, matches, paper.

Instructional Procedure:
Step 1

- Teacher presents students with the instructional objectives
- Teacher inform students about the assessment of their own work and their peer
- Each students will be responsible for a task within the group
- Final mark will be part of group mark of 50% and part of individual task mark of 50% (100%)

Step 2

Teacher revises the previous lesson with the following questions:

1. List five physical and chemical properties of sulphur
2. Explain two chemical properties of sulphur with equation

Step 3

Teacher introduces and develops the lesson by explaining the allotropes of sulphur and uses of sulphur

Allotropes of Sulphur

Rhombic (□-sulphur): Free sulphur exist as rhombic sulphur in nature because it is the only stable allotrope at temperatures below $96^{o}C$. Crystals of Rhombic sulphur are bright yellow and octahedral. They are made up of S_8 molecules. Each S_8 molecule consists if a ring of eight atoms. It is prepared by allowing saturated solution of sulphur in carbon (iv) sulphide to evaporate slowly. Octahedral crystals will gradually be deposited.

a. **Monoclinic or prismatic sulphur:** This is the only stable allotrope at temperature between $96^{0}C$ and $119^{o}C$. The crystals are long, thin and needle shaped, amber in colour and consist of S_8 molecules. At room temperature they slowly revert to rhombic sulphur crystals. They are less dense than rhombic sulphur. This is because the S_8 molecules are more tightly packed in rhombic sulphur than in monoclinic sulphur. Monoclinic sulphur is obtained by cooling molten sulphur.

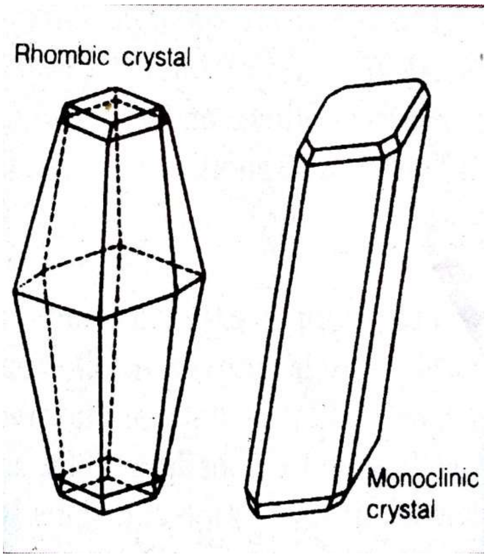

Fig. 6: Structure of Rhombic and Monoclinic sulphur

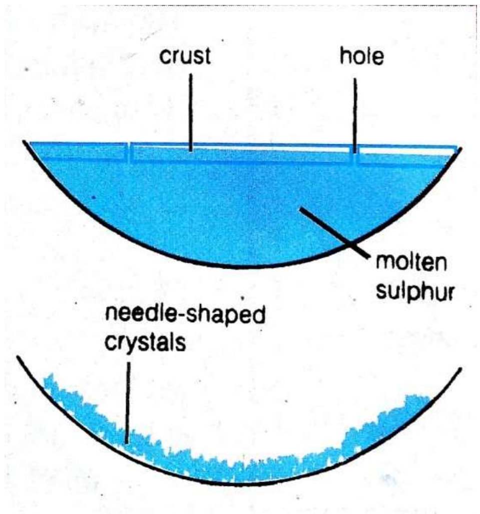

Fig. 7: Preparation of Monoclinic sulphur

b. **Amorhpous sulpur (□-sulphur):** Amorphous sulphur has no regular crystalline shape. It is prepared as a pale yellow, almost white deposit when hydrogen sulphide is bubbled through water for a long time and the saturated solution is exposed to air. It is also deposited in chemical reactions e.g. by the action of hydrochloric acid on a trioxothiosulphate (VI) solution.

c. **Plastic sulphur:** Plastic sulphur is a super-cooled form of sulphur. If yellow sulphur is heated and poured into cold water, it will roll up into yellow ribbons which look as if they are made of plastic materials. It is soft and elastic and will not dissolve in carbon (IV) sulphide. Plastic sulphur is generally not considered to be a true allotrope of sulphur because it is unstable and reverts to rhombic sulphur on standing

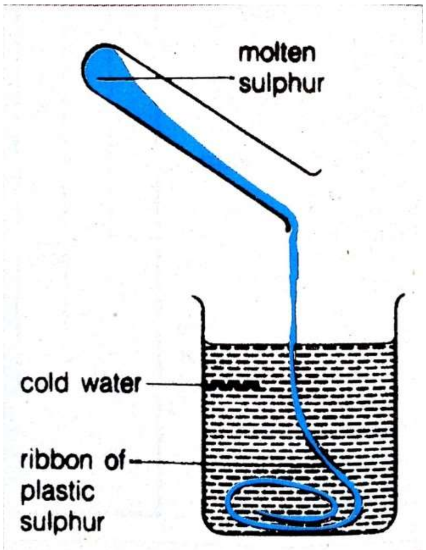

Figure 8: Preparation of Plastic sulphur

Uses of Sulphur

1. Sulphur is used to produce sulpur (IV) oxide for manufacturing tetraoxosulphate (VI) acid.
2. Sulphur is used in the vulcanization of rubber.
3. Sulphur and some of its products are used as fungicides and insecticides for spraying crops.
4. Sulphur is used to manufacture the bleaching agent used in the pulp and paper industry.
5. It is also used for the production of carbon (IV) sulphide, skin ointments and dyes.

Step IV

Based on students passed academic records, students are shared into heterogeneous group in the lesson. Students are given the following activities to work in group.

Questions

1. List and describe the allotropes of sulphur
2. Explain at least three uses of sulphur

Fig. 9: Heterogeneous Grouping of students within the teaching-learning process

Step 5

Teacher moves round the group to see how the students are engaged in the learning task.

Step 6

Based on the feedback from students self assessment, peer assessment and teacher assessment (formative evaluation), students are grouped into homogeneous group so that students who need extra help can get more attention while those who do not need extra help are given something else to do to reinforce the lesson. Students are given the following activities to work in group

Questions

1. List and describe the allotropes of sulphur
2. Explain at least three uses of sulphur

Fig. 10: Homogeneous Grouping of students within the teaching-learning process

Step 7

Based on teacher assessment feedback on the homogeneous group, the groups are rearranged into a whole class and the teacher summarizes the lesson and gives students summative evaluation.

1. List three allotropes of sulphur and explain any one of them
2. List five uses of sulphur

Step 8

Teacher gives the following assignment to the students

1. List five compounds of sulphur
2. Explain the preparation of hydrogen sulphied

LESSON NOTE ON COOPERATIVE LEARNING METHOD

WEEK 4

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^{+}

Mental Ability: Mixed

Topic: Sulphur and its compound (Compounds of sulphur).

Entry Behaviour: Students can describe the different allotropes of sulphur and their uses.

Instructional Objectives: At the end of the lesson, given a chart of compound of sulphur and periodic table students should be able to:

1. List five compounds of sulphur
2. Explain the preparation of hydrogen sulphide

Instructional Materials: New school chemistry by Osei Yaw Ababio, dilute hydrochloric acid, Iron (II) sulphide, litmus paper, filter paper, lead(II) trioxonitrate(V), Kipp's apparatus.

Instructional Procedure:

Step 1

- Teacher presents students with the instructional objectives
- Teacher inform students about the assessment of their own work and their peer
- Each students will be responsible for a task within the group
- Final mark will be part of group mark of 50% and part of individual task mark of 50% (100%)

Step 2

Teacher revises the previous lesson with the following questions:

1. List and explain three allotropes of sulphur
2. Enumerates five uses of sulphur

Step 3

Teacher introduces and develops the lesson by listing the compounds of sulphur and explaining the preparation of hydrogen sulphide using the Kipp's apparatus.

Compounds of Sulphur

Some of the important compounds of sulphur are tetraoxosulphate (vi)acid, trioxosulphate (iv) acids, hydrogen sulphide, sulphur (iv) oxide and tetraoxosulphate salts.

Preparation of Hydrogen Sulphide

Hydrogen sulphide is prepared both in the laboratory and commercially by the action of dilute hydrochloric acid on a metallic sulphide, likr Iron(II) sulphide.

$2HCl_{(aq)} + FeS_{(s)} \rightarrow FeCl_{2(aq)} + H_2S_{(g)}$

$H_2SO_{4(aq)} + FeS_{(s)} \rightarrow FeSO_{4(aq)} + H_2S_{(g)}$

Ionically,

$2H^+_{(aq)} + FeS_{(s)} \rightarrow Fe^{2+} + H_2S_{(g)}$

Step IV

Based on students passed academic records, students are shared into heterogeneous group in the lesson. Students are given the following activities to work in group.

Questions

1. List five compounds of sulphur
2. Explain the preparation of hydrogen sulphide

Fig. 11: Heterogeneous Grouping of students within the teaching-learning process

Step 5

Teacher moves round the group to see how the students are engaged in the learning task.

Step 6

Based on the feedback from students self assessment, peer assessment and teacher assessment (formative evaluation), students are grouped into homogeneous group so that students who need extra help can get more attention while those who do not need extra help are given something else to do to reinforce the lesson. Teacher give students the following activities to work in group

Questions

1. List five compounds of sulphur
2. Explain the preparation of hydrogen sulphide

Fig. 12: Homogeneous Grouping of students within the teaching-learning process

Step 7

Based on teacher assessment feedback on the homogeneous group, the groups are rearranged into a whole class and the teacher summarizes the lesson and gives students summative evaluation.

1. Give examples of some important compounds of sulphur
2. Describe the preparation of hydrogen sulphide using the Kipp's apparatus

Step 8

Teacher gives the following assignment to the students

1. Describe the industrial preparation of H_2SO_4 by contact process.

LESSON NOTE ON COOPERATIVE LEARNING METHOD

WEEK 5

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^+

Mental Ability: Mixed

Topic: Sulphur and its compound (Industrial Preparation of H_2SO_4).

Entry Behaviour: Students can explain the preparation of H_2S.

Instructional Objectives: At the end of the lesson, given a chart of the preparation of H_2SO_4 students should be able to:

1. Describe the industrial preparation of H_2SO_4 by Contact process.

Instructional Materials: New school chemistry by Osei Yaw Ababio, dilute hydrochloric acid, Iron (II) sulphide, litmus paper, filter paper, lead(II) trioxonitrate(V), Kipp's apparatus.

Instructional Procedure:

Step 1

- Teacher presents students with the instructional objectives
- Teacher inform students about the assessment of their own work and their peer
- Each students will be responsible for a task within the group
- Final mark will be part of group mark of 50% and part of individual task mark of 50% (100%)

Step 2

Teacher revises the previous lesson with the following questions:

1. Explain the preparation of hydrogen sulphide

Step 3

Teacher introduces and develops the lesson by explaining the preparation of H_2SO_4.

H_2SO_4

Tetraoxosulphate(VI) acid is one of the most important chemical compounds known to be commonly used in laboratory.

Industrial Preparation of H_2SO_4

Tetraoxosulphate(VI) acid is manufactured by contact process. The main reaction in the process is the catalytic combination of sulphur (VI) oxide and oxygen to sulphur (IV) oxide.

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) + heat$$

The sulphur(IV) oxide is then mixed with excess air and passed through an electric chamber to remove impurities and dust which might poison the catalyst. The gaseous mixture is then passed through concentrated (VI) acid to be dried before it is delivered to reaction chamber or contact tower. In this chamber, sulphur (VI) oxide, to yield sulphur (VI) oxide combines with oxygen in the presence of pellets of the catalyst, vanadium (v) oxide, to yield sulphur (VI) oxide.

The process is operated at atmospheric pressure and a temperature of about 450-500^oC, with an excess of air or oxygen to ensure that all the sulphur (IV) oxide has reacted. About 98% of the possible yield of sulphur(VI) oxide is obtained.

The sulphur(IV) oxide is cooled and passed into an absorption tower where it dissolves into concentrated tetraoxosulphate(VI) acid to produce a very thick liquid called oleum. The oxide is not dissolved directly in water because the heat evolved during the process would cause the acid solution to boil, producing a mist of acid droplets which would spread throughout the factory.

$$SO_3(g) + H_2SO_4(aq) \rightarrow H_2S_2O_7(aq)$$

The oleum is diluted with appropriate amount of water to produce the 98% tetraoxosulphate (vi) acid used in the laboratory.

$$H_2S_2O_7(aq) + H_2O(l) \rightarrow 2H_2SO_4(aq)$$

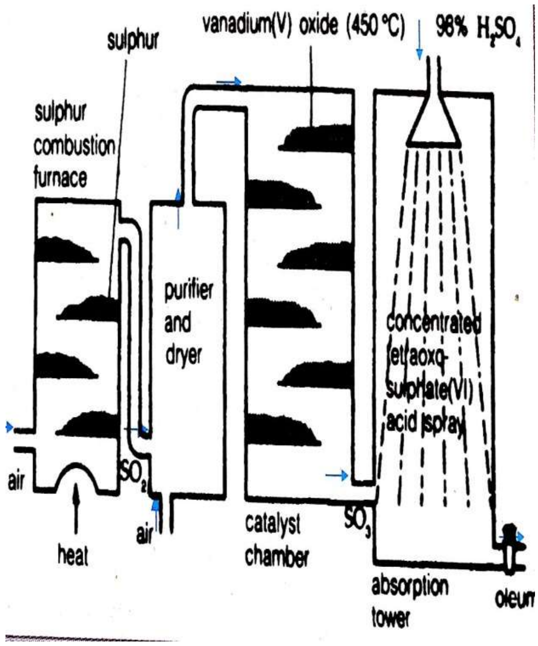

Figure 13: Preparation of tetraoxosulphate (VI) acid by the contact process

Step IV

Based on students passed academic records, students are shared into heterogeneous group in the lesson. Students are given the following activities to work in group.

Questions

1. Describe the industrial preparation of H_2SO_4 by contact process

Fig. 14: Heterogeneous Grouping of students within the teaching-learning process

Step 5

Teacher moves round the group to see how the students are engaged in the learning task.

Step 6

Based on the feedback from students self assessment, peer assessment and teacher assessment (formative evaluation), students are grouped into homogeneous group so that students who need extra help can get more attention while those who do not need extra help are given something else to do to reinforce the lesson. Students are given the following activities to work in group.

Questions

1. Describe the industrial preparation of H_2SO_4 by contact process

Fig. 15: Homogeneous Grouping of students within the teaching-learning process

Step 7

Based on teacher assessment feedback on the homogeneous group, the groups are rearranged into a whole class and the teacher summarizes the lesson and gives students summative evaluation.

3. Describe the contact process for the preparation of H_2SO_4

Step 8

Teacher gives the following assignment to the students

1. List three physical properties of H_2SO_4
2. Explain the chemical properties of H_2SO_4
3. List five uses of H_2SO_4

LESSON NOTE ON COOPERATIVE LEARNING METHOD

WEEK 6

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^+

Mental Ability: Mixed

Topic: Sulphur and its compound (Properties and uses of H_2SO_4).

Entry Behaviour: Students can explain the preparation of H_2SO_4.

Instructional Objectives: At the end of the lesson, given a chart of the properties and uses of H_2SO_4 students should be able to:

1. List three physical properties of H_2SO_4.
2. List five uses of H_2SO_4.

Instructional Materials: New school chemistry by Osei Yaw Ababio, dilute hydrochloric acid, fertilizers, litmus paper, test-tube, beekers.

Instructional Procedure:

Step 1

- Teacher presents students with the instructional objectives
- Teacher inform students about the assessment of their own work and their peer
- Each students will be responsible for a task within the group
- Final mark will be part of group mark of 50% and part of individual task mark of 50% (100%)

Step 2

Teacher revises the previous lesson with the following question:

1. Explain the preparation of tetraoxosulphate(VI) acid.

Step 3

Teacher introduces and develops the lesson by explaining the physical properties and uses of H_2SO_4.

Physical Properties of H_2SO_4

1. Concentrated H_2SO_4 often called the oil of vitriol is a colourless, viscous liquid with a density of 1.84 g cm^{-3}.
2. It is corrosive and causes severe burns if it comes in contact with the skin
3. It has a great affinity for water, evolving a large amount of heat as it dissolves.

Chemically, H_2SO_4 reacts as an acid, an oxidizing agent, a dehydrating agent and displaces other acids from their salts.

Uses of H_2SO_4

1. About one quarter of H_2SO_4 produced in the world is used for the manufacture of fertilizer.
2. Large amount of acid is used in the manufacture of pigments for use in paints and dyes.
3. It is used for making cellulose films, natural and artificial fabrics, and plastics.
4. The acid is used in the purification of crude oil and also in the manufacture of artificial silk.
5. It is used for making cellulose films, natural and artificial fabrics, and plastics.
6. The acid is used to clean or pickle metals before electroplating or enameling.
7. It is used as electrolyte in lead acid accumulators and batteries and in refining metals by electrolysis.
8. It is used as a dehydrating agent in the nitration of compounds used for making explosives.
9. In the refining of petroleum, the acid is used to remove waxes, gums and many dark-coloured compounds.
10. It is used in the preparation of many important chemical compounds e.g. hydrochloric and trioxonitrate (V) acids, metallic tetraoxosulphate(VI), and many others.

Step IV

Based on students passed academic records, students are shared into heterogeneous group in the lesson. Students are given the following activities to work in group.

Questions

1. List three physical properties of H_2SO_4
2. List five uses of H_2SO_4

Fig. 16: Heterogeneous Grouping of students within the teaching-learning process

Step 5

Teacher moves round the group to see how the students are engaged in the learning task.

Step 6

Based on the feedback from students self assessment, peer assessment and teacher assessment (formative evaluation), students are grouped into homogeneous group so that students who need extra help can get more attention while those who do not need extra help are given something else to do to reinforce the lesson. Students are given the following activities to work in group.

Questions

1. List three physical properties of H_2SO_4
2. List five uses of H_2SO_4

Fig. 17: Homogeneous Grouping of students within the teaching-learning process

Step 7

Based on teacher assessment feedback on the homogeneous group, the groups are rearranged into a whole class and the teacher summarizes the lesson and gives students summative evaluation.

1. List three physical properties of H_2SO_4
2. List five uses of H_2SO_4

APPENDIX B

LESSON NOTE ON LECTURE METHOD

WEEK 1

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^{+}

Mental Ability: Mixed

Topic: Sulphur and its compound (Occurrence and Extraction of Sulphur).

Entry Behaviour: Students can state the properties of P-block elements.

Instructional Objectives: At the end of the lesson, given periodic table and chart of sulphur students should be able to:

1. Describe the general properties of group VI element
2. Describe the electronic structure of sulphur
3. Describe the occurrence and extraction of sulphur by Frasch process

Instructional Materials: New school chemistry by Osei Yaw Ababio, chart of sulphur and its compounds, sulphuric acid, water, litmus paper.

Instructional Procedure:

Step 1: Routine

Teacher asks students to stand up, greet, bring out their writing materials and sit down.

Step 2: Revision

Teacher asks the following questions based on the previous lesson:

1. Give 2 uses of any oxide of nitrogen
2. Give four uses of ammonia

Step 3: Introduction

Teacher introduces the lesson by writing the topic on the board place the charts showing sulphur and its compound on the board.

Step 4: Development

Teacher explains in details the contents of the lesson as related to the stated objectives and asks students to write down the following.

Sulphur

Sulphur belongs to group 6 of the periodic table. The sulphur atom like all group six members has six valence electrons. In order to achieve an octect structure, it gains two electrons, usually from group 1 and 2 metals, to form a divalent sulphide ion, S^{2-}. With non-metals, sulphur attain octect structure by sharing electrons to form covalent compounds such as hydrogen sulphide, H-S-H. The oxidation state of sulphur can range from -2 to +6. Sulphur has been known for its medicinal and germicidal effect. It makes up about 0.1% of the earth's crust. It occurs freely as deposit in U.S.A, Poland, Japan, New Zealand and Sicily. It is widely found in the combined state as suphides of iron, zinc, lead, copper and mercury, and as tetraoxosulphate (VI) salts of calcium, magnesium and barium. Sulphur is also present in some proteins.

Extraction of Sulphur

The extraction of sulphur from its underground deposit of more than 200m below the earth's surface is based on the Frasch process. A hole about 30cm in diameter is drilled through the soil to the sulphur bed. A sulphur pipe made of three concentric pipes is then driven down the hole. Super-heated water of about 170^{o}C and 10 atm pressure is forced through the outermost tube to the sulphur bed to melt the sulphur. Hot compressed air at a pressure of 15 atm is then blown down the inmost tube to force the sulphur up through the middle tube. The molten sulphur is continually pumped into a receptacle at the surface where it is allowed to solidify in large tanks. The sulphur obtained is about 99.5% pure.

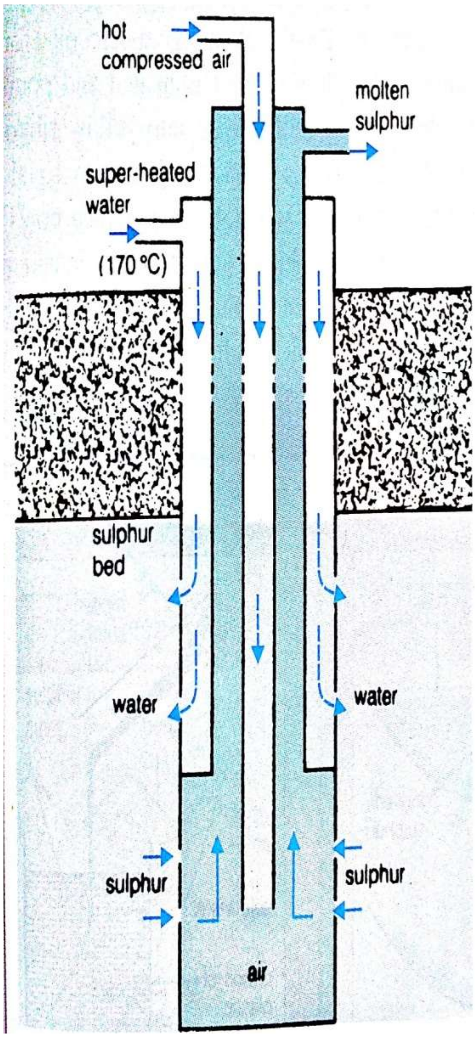

Figure 1: Extraction of sulphur (Frasch process)

Step 5: Application

Teacher ask students to describe the electronic configuration of sulphur

Step 6: Summary/Evaluation

Teacher summarizes the lesson and evaluates students by asking the following questions:

1. Describe the general properties of group VI elements and electronic structure of sulphur
2. Describe the occurrence and extraction of Sulphur by Frasch process

Step 7: Assignment

1. State five physical properties of sulphur
2. State three chemical properties of sulphur with equation

LESSON NOTE ON LECTURE METHOD

WEEK 2

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^+

Mental Ability: Mixed

Topic: Sulphur and its compound (Physical and Chemical Properties of Sulphur).

Entry Behaviour: Students can explain the occurrence and extraction of sulphur.

Instructional Objectives: At the end of the lesson, given the periodic table and chart of sulphur students should be able to:

1. State five physical properties of sulphur
2. Describe three chemical properties of suphur

Instructional Materials: New school chemistry by Osei Yaw Ababio, chart of sulphur and its compounds, sulphuric acid, water, litmus paper.

Instructional Procedure:

Step 1: Routine

Teacher asks students to stand up, greet, bring out their writing materials and sit down.

Step 2: Revision

Teacher asks the following questions based on the previous lesson:

1. Describe the electronic structure of sulphur
2. Describe the occurrence and extraction of sulphur

Step 3: Introduction

Teacher introduces the lesson by writing the topic on the board

Step 4: Development

Teacher explain in details the contents of the lesson as related to the stated objectives with available multimedia learning materials and asks students to write down the following.

Physical properties of Sulphur

1. Sulpur is a yellow solid. It exists in two forms of amorphous and crystalline.
2. It is insoluble in water but in carbon (iv) sulphide and methyl benzene (toluene)
3. It is a bad conductor of heat and electricity.
4. Density depends on allotropic form.
5. It has a melting point of 119°C and a boiling point of 444°C.

Chemical properties of Sulphur

1. **Direct combination with other elements:**

With metals: sulphur combines directly with metals to form sulphides when heated in the absence of air.

$$Fe(s) + S(s) \rightarrow FeS(s)$$

With Oxygen: When sulphur is heated in plentiful supply of air, it burns with a brightly yellow flame to form sulphur (IV) oxide and a small amount of sulphur (VI) oxide.

$$O_2(g) + S(s) \rightarrow SO_2(g)$$

With Carbon: sulphur combines with coke in an electric furnance to form a colourless liquid known as carbon (IV) sulphide, which vapourizes readily, forming poisonous and highly flammable fumes.

$$C(s) + 2S(s) \rightarrow CS_2(l)$$

With other non-metals: sulphur combines with other non-metals to form various sulphides, e.g. tetraphosporus trisulphide, P_4S_3, disulphide dichloride, S_2Cl_2, and sulphur hexafluoride, SF_6.

2. **Action of oxidizing acids:** Sulphur is readily oxidized when warmed with concentrated tetraoxosulphate (VI) acid to form sulphur (VI) oxide.

$$2H_2SO_4(aq) + S(s) \rightarrow 2H_2O(l) + 3SO_2(g)$$

3. **Action of hot concentrated alkalis:** Sulphur will react with hot concentrated solution to form a mixture of sulphides and trioxosulphates (IV), which, in the presence of excess sulphur, react to form a polysulphide and a trioxothiosulphate (VI) respectively.

$$3S + 6OH^- \rightarrow SO_3^{2-} + 3H_2O$$

Step 5: Application

Teacher ask students to show with equation only the chemical properties of sulphur

Step 6: Summary/Evaluation

Teacher summarizes the lesson and evaluates students by asking the following questions:

1. List 5 physical properties of sulphur

2. List with equations three chemical properties of sulphur.

Step 7: Assignment

Teacher asks students to:

1. List three allotropes of sulphur

2. Enumerate two ways sulphur is used in the chemical industry

LESSON NOTE ON LECTURE METHOD

WEEK 3

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^+

Mental Ability: Mixed

Topic: Sulphur and its compound (Allotropes and uses of sulphur).

Entry Behaviour: Students can explain the physical and chemical properties of sulphur.

Instructional Objectives: At the end of the lesson, given the periodic table and chart of sulphur students should be able to:

1. List and describe three allotropes of sulphur

2. Explain at least three uses of sulphur

Instructional Materials: New school chemistry by Osei Yaw Ababio, chart of sulphur allotropes, fungicides and insecticides made of sulphur compounds, matches, paper.

Instructional Procedure:

Step 1: Routine

Teacher asks students to stand up, greet, bring out their writing materials and sit down.

Step 2: Revision

Teacher asks the following questions based on the previous lesson:

1. List five physical chemical properties of sulphur
2. Explain two chemical properties of sulphur with equation

Step 3: Introduction

Teacher introduces the lesson by writing the topic on the board

Step 4: Development

Teacher explain in details the contents of the lesson as related to the stated objectives with available multimedia learning materials and asks students to write down the following.

d. **Rhombic (□-sulphur):** Free sulphur exist as rhombic sulphur in nature because it is the only stable allotrope at temperatures below $96^{o}C$. Crystals of Rhombic sulphur are bright yellow and octahedral. They are made up of S_8 molecules. Each S_8 molecule consists if a ring of eight atoms. It is prepared by allowing saturated solution of sulphur in carbon (iv) sulphide to evaporate slowly. Octahedral crystals will gradually be deposited.

e. **Monoclinic or prismatic sulphur:** This is the only stable allotrope at temperature between $96^{0}C$ and $119^{o}C$. The crystals are long, thin and needle shaped, amber in colour and consist of S_8 molecules. At room temperature they slowly revert to rhombic sulphur crystals. They are less dense than rhombic sulphur. This is because the

S_8 molecules are more tightly packed in rhombic sulphur than in monoclinic sulphur. Monoclinic sulphur is obtained by cooling molten sulphur.

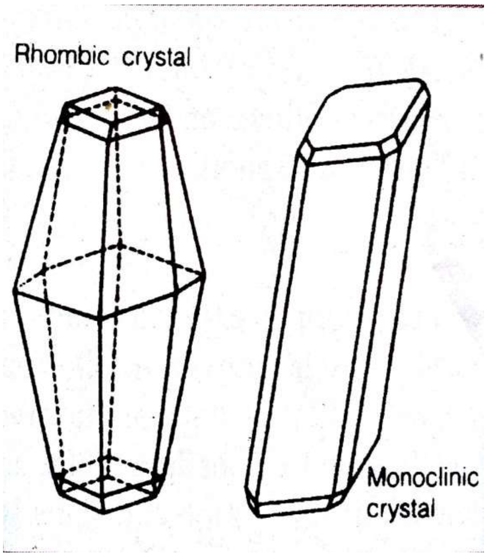

Fig. 2: Structure of Rhombic and Monoclinic sulphur

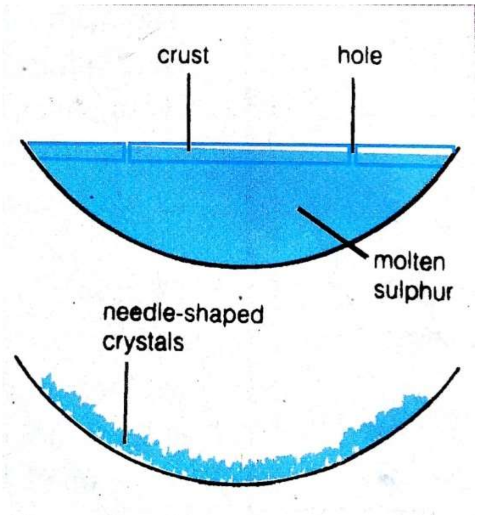

Figure 3: Preparation of Monoclinic sulphur

f. **Amorhpous sulpur (□-sulphur):** Amorphous sulphur has no regular crystalline shape. It is prepared as a pale yellow, almost white deposit when hydrogen sulphide is bubbled through water for a long time and the saturated solution is exposed to air. It is also deposited in chemical reactions e.g. by the action of hydrochloric acid on a trioxothiosulphate (VI) solution.

g. **Plastic sulphur:** Plastic sulphur is a super-cooled form of sulphur. If yellow sulphur is heated and poured into cold water, it will roll up into yellow ribbons which look as if they are made of plastic materials. It is soft and elastic and will not dissolve in carbon (IV) sulphide. Plastic sulphur is generally not considered to be a true allotrope of sulphur because it is unstable and reverts to rhombic sulphur on standing

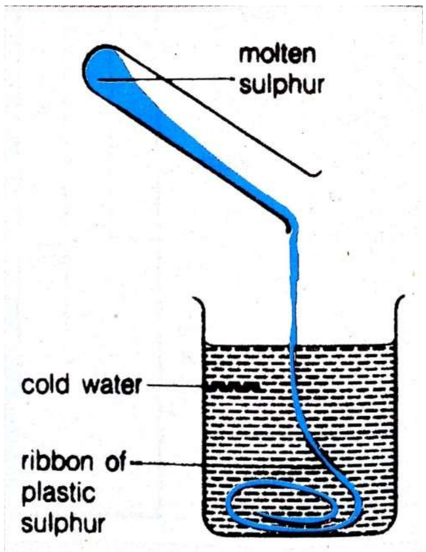

Figure 4: Preparation of Plastic sulphur

Uses of Sulphur

1. Sulphur is used to produce sulpur (IV) oxide for manufacturing tetraoxosulphate (VI) acid.
2. Sulphur is used in the vulcanization of rubber.
3. Sulphur and some of its products are used as fungicides and insecticides for spraying crops.

4. Sulphur is used to manufacture the bleaching agent used in the pulp and paper industry.

5. It is also used for the production of carbon (IV) sulphide, skin ointments and dyes.

Step 5: Application

Teacher asks students to:

1. Explain the structure of rhombic sulphur
2. Describe the preparation of plastic sulphur

Step 6: Summary/Evaluation

Teacher summarizes the lesson and evaluates students by asking the following questions:

1. List three allotropes of sulphur and explain any one of them
2. List five uses of sulphur.

Step 7: Assignment

Teacher asks students to:

1. List the common compounds of sulphur
2. Describe the preparation of hydrogen sulphide using Kipp's apparatus

LESSON NOTE ON LECTURE METHOD

WEEK 4

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^{+}

Mental Ability: Mixed

Topic: Sulphur and its compound (Compounds of sulphur).

Entry Behaviour: Students can describe the different allotropes of sulphur and their uses.

Instructional Objectives: At the end of the lesson, given chart of compound of sulphur and periodic table students should be able to:

1. List five compounds of sulphur
2. Explain the preparation of hydrogen sulphide

Instructional Materials: New school chemistry by Osei Yaw Ababio, dilute hydrochloric acid, Iron (II) sulphide, litmus paper, filter paper, lead(II) trioxonitrate(V), Kipp's apparatus.

Instructional Procedure:

Step 1: Routine

Teacher asks students to stand up, greet, bring out their writing materials and sit down.

Step 2: Revision

Teacher asks the following questions based on the previous lesson:

1. List and explain three allotropes of sulphur
2. Enumerates five uses of sulphur

Step 3: Introduction

Teacher introduces the lesson by writing the topic on the board

Step 4: Development

Teacher explains in details the contents of the lesson as related to the stated objectives with the aid of a video presentation and asks students to write down the following.

Compounds of Sulphur

Some of the important compounds of sulphur are tetraoxosulphate (vi)acid, trioxosulphate (iv) acids, hydrogen sulphide, sulphur (iv) oxide and tetraoxosulphate salts.

Preparation of Hydrogen Sulphide

Hydrogen sulphide is prepared both in the laboratory and commercially by the action of dilute hydrochloric acid on a metallic sulphide, likr Iron(II) sulphide.

$2HCl_{(aq)} + FeS_{(s)} \rightarrow FeCl_{2(aq)} + H_2S_{(g)}$

$H_2SO_{4(aq)} + FeS_{(s)} \rightarrow FeSO_{4(aq)} + H_2S_{(g)}$

Ionically,

$2H^{+}_{(aq)} + FeS_{(s)} \rightarrow Fe^{2+} + H_2S_{(g)}$

The gas is easily liquefied and may be purchased in this form in steel cylinders.

Step 5: Application

Teacher asks students to:

1. List the components of the Kipp's apparatus

Step 6: Summary/Evaluation

Teacher summarizes the lesson and evaluates students by asking the following questions

1. Give examples of some important componds of sulphur
2. Describe the preparation of hydrogen sulphide using the Kipp's apparatus

Step 7: Assignment

Teacher asks students to contact process of preparing H_2SO_4

LESSON NOTE ON LECTURE METHOD

WEEK 5

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^+

Mental Ability: Mixed

Topic: Sulphur and its compound (Industrial Preparation of H_2SO_4).

Entry Behaviour: Students can explain the preparation of H_2S.

Instructional Objectives: At the end of the lesson, given a chart of preparation of H_2SO_4 students should be able to:

1. Describe the industrial preparation of H_2SO_4 by Contact process.

Instructional Materials: New school chemistry by Osei Yaw Ababio, dilute hydrochloric acid, Iron (II) sulphide, litmus paper, filter paper, lead(II) trioxonitrate(V), Kipp's apparatus.

Instructional Procedure:

Step 1: Routine

Teacher asks students to stand up, greet, bring out their writing materials and sit down.

Step 2: Revision

Teacher asks students to explain the preparation of hydrogen sulphide

Step 3: Introduction

Teacher introduces the lesson by writing the topic on the board

Step 4: Development

Teacher explains in details the contents of the lesson as related to the stated objectives with the aid of a video presentation and asks students to write down the following.

Tetraoxosulphate(VI) acid

Tetraoxosulphate(VI) acid is one of the most important chemical compounds known to be commonly used in laboratory.

Industrial Preparation of H_2SO_4

Tetraoxosulphate(VI) acid is manufactured by contact process. The main reaction in the process is the catalytic combination of sulphur (VI) oxide and oxygen to sulphur (IV) oxide.

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g) + \text{heat}$$

The sulphur(IV) oxide is then mixed with excess air and passed through an electric chamber to remove impurities and dust which might poison the catalyst. The gaseous mixture is then passed through concentrated (VI) acid to be dried before it is delivered to reaction chamber or contact tower. In this chamber, sulphur (VI) oxide, to yield sulphur (VI) oxide combines with oxygen in the presence of pellets of the catalyst, vanadium (v) oxide, to yield sulphur (VI) oxide.

The process is operated at atmospheric pressure and a temperature of about 450-500^{o}C, with an excess of air or oxygen to ensure that all the sulphur (IV) oxide has reacted. About 98% of the possible yield of sulphur(VI) oxide is obtained.

The sulphur(IV) oxide is cooled and passed into an absorption tower where it dissolves into concentrated tetraoxosulphate(VI) acid to produce a very thick liquid called oleum. The oxide is not dissolved directly in water because the heat evolved during the process would cause the acid solution to boil, producing a mist of acid droplets which would spread throughout the factory.

$$SO_3(g) + H_2SO_4(aq) \rightarrow H_2S_2O_7(aq)$$

The oleum is diluted with appropriate amount of water to produce the 98% tetraoxosulphate (vi) acid used in the laboratory.

$$H_2S_2O_7(aq) + H_2O(l) \rightarrow 2H_2SO_4(aq)$$

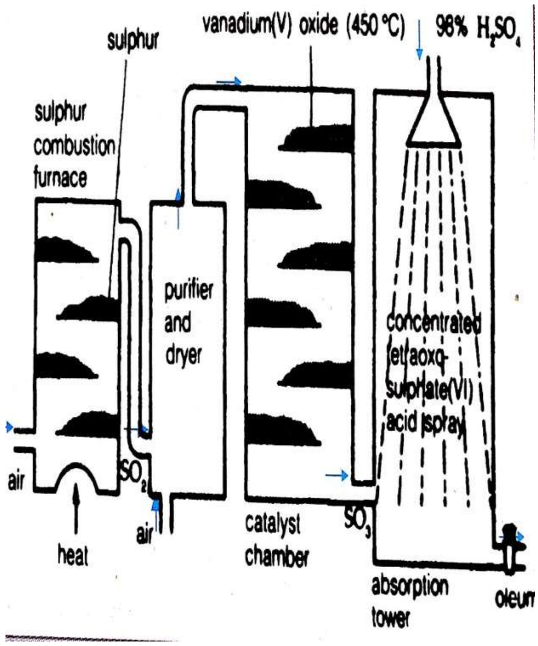

Figure 4: Preparation of tetraoxosulphate (VI) acid by the contact process

Step 5: Application

Teacher asks students to explain the function of vanadium(V) oxide in the preparation of H_2SO_4.

Step 6: Summary/Evaluation

Teacher summarizes the lesson and evaluates students by asking students to explain the contact process of preparing tetraoxosulphate(VI) acid.

Step 7: Assignment

Teacher asks students to:

1. Mention three physical properties of H_2SO_4
2. List five uses of H_2SO_4

LESSON NOTE ON LECTURE METHOD

WEEK 6

Date:

Duration: 80mins (Double Period, 40mins per period)

Class: Senior Secondary Two (SSII)

Age: 16^+

Mental Ability: Mixed

Topic: Sulphur and its compound (Properties and uses of H_2SO_4).

Entry Behaviour: Students can explain the preparation of H_2SO_4.

Instructional Objectives: At the end of the lesson, given a chart of properties and uses of H_2SO_4 students should be able to:

1. List three physical properties of H_2SO_4.
2. List five uses of H_2SO_4.

Instructional Materials: New school chemistry by Osei Yaw Ababio, dilute hydrochloric acid, fertilizers, litmus paper, test-tube, beekers.

Instructional Procedure:

Step 1: Routine

Teacher asks students to stand up, greet, bring out their writing materials and sit down.

Step 2: Revision

Teacher asks students to explain the preparation of tetraoxosulphate(VI) acid

Step 3: Introduction

Teacher introduces the lesson by writing the topic on the board

Step 4: Development

Teacher explains in details the contents of the lesson as related to the stated objectives and asks students to write down the following.

Physical Properties of H_2SO_4

1. Concentrated H_2SO_4 often called the oil of vitriol is a colourless, viscous liquid with a density of 1.84 g cm^{-3}.
2. It is corrosive and causes severe burns if it comes in contact with the skin
3. It has a great affinity for water, evolving a large amount of heat as it dissolves.

Chemically, H_2SO_4 reacts as an acid, an oxidizing agent, a dehydrating agent and displaces other acids from their salts.

Uses of H_2SO_4

1. About one quarter of H_2SO_4 produced in the world is used for the manufacture of fertilizer.
2. Large amount of acid is used in the manufacture of pigments for use in paints and dyes.
3. It is used for making cellulose films, natural and artificial fabrics, and plastics.
4. The acid is used in the purification of crude oil and also in the manufacture of artificial silk.
5. It is used for making cellulose films, natural and artificial fabrics, and plastics.

6. The acid is used to clean or pickle metals before electroplating or enameling.
7. It is used as electrolyte in lead acid accumulators and batteries and in refining metals by electrolysis.
8. It is used as a dehydrating agent in the nitration of compounds used for making explosives.
9. In the refining of petroleum, the acid is used to remove waxes, gums and many dark-coloured compounds.
10. It is used in the preparation of many important chemical compounds e.g. hydrochloric and trioxonitrate (V) acids, metallic tetraoxosulphate(VI), and many others.

Step 5: Application

Teacher asks students to identify any chemical fertilizer produced with H_2SO_4

Step 6: Summary/Evaluation

Teacher summarizes the lesson and evaluates students by asking students to:

1. List any 5 physical properties of H_2SO_4
2. Mention any 8 uses of H_2SO_4

APPENDIX C

CHEMISTRY ACHIEVMENT TEST (CAT)

NAME OF STUDENT: DATE:

GENDER: Male ( ) Female ( ) TIME: 50 MINUTES

Instruction: Circle the correct answer from the options provided

1. Sulphur belongs to group _ of the periodic table
   A 6 B 2 C 4 D 5
2. In order to achieve octect structure, sulphur gains two electrons usually from groups
   A 1 & 2 B 2 & 3 C 3 & 4 D 4 & 5
3. The oxidation state of sulphur can range from
   A +2 to +6B +2 to -6 C -2 to +6 D -2 to -6
4. Sulphure exists in combined state as sulphides with
   A Calcium B Magnsesium C Iron D chlorine
5. The process for the extraction of sulphur is called ____ process
   A Haber B Frasch C Contact process D Marsh process
6. Free sulphur exist as __ sulphur
   A Rhomic B Monoclinic C amorphous D plastic
7. Sulphur is a __ solid
   A Blue B Green C Red D Yellow
8. Sulphur combines with metals to form ___
   A sulphides B sulphric acid C sulphates D thiosulphates
9. One compound of sulphur known for its poisonous and highly flammable quality is

   A FeSB SO_3 C CS_2 D SO_2
10. Sulphur is used in all of the following except
    A fireworks B matches C gunpowder D body creams
11. Tetraoxosulphate (vi) acid is manufactured by __ process
    A Haber B Frasch C Contact D Marsh
12. sulphur (iv) oxide dissolves into concentrated tetraoxosulphate (vi) acid to produce
    A oleum B oil C plastic D sulpur powder
13. Tetraoxosulphate (vi) acid has a density of
    A 1.81 g cm^{-3} B 1.84 g cm^{-3} C 8.14 g cm^{-3} D 1.48 g cm^{-3}
14. Which of the following is used in cellulose films
    A H_2SO_4 B HNO_3 C H_2S D SO_2

15. One very important and worldwide use of sulphur is in the making of ___
A Film straps B Fertilizer C Chemicals D Dehydrating agents
16. The type of bond in H-S-H is
A ionic bond B Dative bond C Covalent bond D Hydrogen bond
17. Sulphur obtained through Frasch process is __ pure A 99.5% B 59.5%
C 59.9% D 95.9%
18. The only stable allotrope of sulphur at temperature between 96^0C and 119^oC is
A rhomic B monoclinic C amorphous D plastic
19. Which of the following is used for making artificial silk
A H_2SO_4 B HCl C MgCl D HNO_4
20. The melting point of Sulphur is
A 919 ^{o}C B 991^{o}C C 191^{o}C D 119^{o}C
21. ------- recognize sulphur as an element A. Dalton B. Laivoisier C. Graham D. Bohr
22. In what year was sulphur recognize as an element A. 1787 B. 1887 C. 1687 D. 1987
23. What is the percentage of sulphur in the earth crust A. 0.1% B. 1.0% C. 0.2% D. 2.0%
24. ----- is the catalyst used in the separation of H_2S from natural gas A. Vanadium B. lead C. platinum D. bauxite
25. The temperature at which sulphur attropes changes from one form to another is known as – A. metamorphic temperature B. transition temperature C. solid state temperature D. vulcanizing temperature.
26. ------ Sulphide are use in the production of H_2S A. acidic B. basic C. metallic C. amphoteric
27. ------ apparatus allows a gas to be supplied any time it is required A. Gibb's B. Klebb's C. Kipp's D. Einstein
28. ----- is a colourless gas with a repulsive smell like that of a rotten egg A. H_2SO_4 B. H_2S C. HNO_2 D. NH_4OH
29. All except ---- are compounds of sulphur A. SO_2 B. H_2S C. H_2SO_4 D. NH_3
30. Plastic sulphur is not generally considered to be a true allotrope of sulphur because it is ----- A. very reactive B. unstable and reverts to rhombic sulphur on standing C. stable and unreactive D. none of the above
31. The crystal of monoclinic sulphur consist of ---- molecules A. S_8 B. S_6 C. S_5 D. S_4
32. Sulphur exists in two forms of ----- and ----- A. amorphous and crystalline B. amorphous and plastic C. rhombic and amorphous D. all of the above
33. The oxidation state of sulphur in SO_2 is A. +4 B. +5 C. +6 D. +7
34. ------- is used in the production of dihydrogentetraoxosulphate(V) fertilizer A. H_2S B. H_2SO_4 C. H_2SO_4 D. none of the above
35. Hot concentrated H_2SO_4 acid exhibits oxidizing properties by accepting ---- from reducing agents A. ions B. protons C. Neutrons D. electrons

36. One of these catalyst is used in the industrial preparation of H_2SO_4 A. platinum B. palladium C. vanadium(V) oxide D. all of the above
37. The operating temperature in the reaction chamber in contact process is between A. 450-500^{0}C B. 350-400^{0}C C. 550-600^{0}C D. 650-700^{0}C
38. Concentrated H_2SO_4 is often called --- A. oil of vitriol B. oil of vitriol C. oil of spirit C. oil of reaction
39. Which of these is dibasic A. HNO_3 B. HCO_3 C. H_2SO_4 D. all of the above
40. The most commonly used metallic sulphide in the preparation of Hydrogen sulphide is ---A. CuS B. PbS C. FeS D. all of the above
41. ----- and some of its products are used as fungicides and insecticides for spraying crops A. nitrogen B. sulphur C. phosphorous D. none of the above
42. Which of these is not an allotrope of sulphur A. rhombic B. prismatic C. charismatic D. plastic sulphur
43. Monoclinic sulphur has ----- shape A. needle B. octahedral C. linear D. paramidal
44. Hot compressed air at a pressure of 15atn is blown down the innermost tube in the Frasch process to ---- A. force molten sulphur up through the middle tube B. to force molten sulphur through the terminal tube C. to force molten sulphur through the peripheral tube D. all of the above
45. Which of these is the formula of oleum A. $H_2S_2O_7$ B.$H_2S_2O_4$ C. H_2SO_3 D. none of the above
46. In the reaction, $2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$ + A, A represent --- A. oxygen B. water C. heat D. all of the above
47. In the reaction between sulphur and oxygen, the product is A. SO B. SO_2 C.SO_3 D. SO_4
48. ------ causes severe burns if it comes in contact with the skin A. conc. H_2SO_4 B. Conc. NaOH C. Conc. Na_2CO_3 D. none of the above
49. Acid that absorb water vapour from the surroundings but do not dissolve in it to form solution are called--- A. efflorescents B. Hygroscopic C. deliquescents D. all of the above
50. ---- is used to clean or pickle metals before electroplating A. H_2S B. H_2SO_4 C. H_2CO_3 D. H_2PO_4

Appendix D

Calculations for reliability coefficient (r) on achievement test for 40 students

Scores of the students on total test obtained from testing are shown below

14	31	10	13	9	23	18	16	18	32
18	8	21	9	20	30	11	21	12	13
18	17	20	10	13	23	15	25	15	25
24	11	12	28	12	14	16	19	20	18

$$r = \frac{Kd^2 - \overline{X}(K - \overline{X})}{d^2(K - 1)}$$

Where,

K = number of items = 40

$\overline{X}$= mean score = 17.55

d = standard deviation = 6.30

$$\mathbf{r} = \frac{40(6.30)^2 - 17.55\,(40 - 17.55)}{6.30^2(40 - 1)}$$

$$r = \frac{1193.6025}{1547.91} = 0.77$$

APPENDIX E

Marking scheme for CAT

1	A	11	C	21	B	31	A	41	B
2	A	12	A	22	A	32	A	42	C
3	C	13	B	23	A	33	A	43	A
4	C	14	A	24	B	34	B	44	A
5	B	15	B	25	B	35	D	45	A
6	A	16	C	26	C	36	C	46	C
7	D	17	A	27	C	37	A	47	B
8	A	18	B	28	B	38	A	48	A
9	C	19	A	29	D	39	C	49	B
10	D	20	D	30	B	40	C	50	B

APPENDIX F

Population of SSII chemistry students in Delta Central Senatorial District of Delta State

S/No	DutyPost	Town	LGA	Number of chemistry students	
				Female	Male
1	Abraka Gram. Sch.	Abraka	Ethiope E	23	28
2	Agbon Sec. Sch.	Isiokolo	Ethiope East	22	29
3	Agbon College	Okpara-Inland	Ethiope East	32	19
4	Egbo Commercial Sec. Sch.	Egbo-Kokori	Ethiope East	40	11
5	Ekpan-Ovu Sec. Sch.	Ekpan-Ovu	Ethiope East	24	27
6	Eku Girls Sec. Sch.	Eku	Ethiope East	35	16
7	Erho Sec. Sch.	Erho-Abraka	Ethiope East	21	30
8	Ibruvwe Sec. Sch.	Samagidi-Kokori	Ethiope East	28	23
9	Igun Sec. Sch.	Igun	Ethiope East	15	35
10	Isiokolo Girls Sec. Sch.	Isiokolo	Ethiope East	31	20
11	Kokori Mixed Sec. School	Kokori	Ethiope East	28	23
12	Kokori Girls Sec. Sch.	Kokori-Inland	Ethiope East	20	31
13	Okpara Boys Sec. Sch.	Okpara-Inland	Ethiope East	35	16
14	Okpara Mixed Sec. Sch.	Okpara-Waterside	Ethiope East	39	12
15	Okurekpo Sec. Sch.	Okurekpo	Ethiope East	41	10
16	Orhoakpo Sec. Sch.	Orhoakpo	Ethiope East	27	23
17	Ojeta Sec. Sch.	Ekrejeta	Ethiope East	17	33
18	Otorho Sec. Sch.	Otorho-Abraka	Ethiope East	40	11
19	Oviorie Sec. Sch.	Oviorie	Ethiope East	17	23
20	Ovu Gram. Sch.	Ovu-Inland	Ethiope East	20	40
21	Ovu College	Urhodo-Ovu	Ethiope East	31	20

22	Owhere Gram. Sch.	Okpara-Waterside	Ethiope East	30	20
23	Umiaghwa Sec. Sch.	Oria-Abraka	Ethiope East	16	34
24	Urhuoka Sec. Sch.	Urhuoka-Abraka	Ethiope East	22	28
25	Baptist Med. Centre Staff Sec. Sch.	Eku	Ethiope East	29	21
26	Boboruku Sec. Sch.	Boboruku	Ethiope West	33	17
27	Idjerhe Sec. Sch.	Jesse	Ethiope West	40	11
28	Ighoyota Sec. Sch.	Ugbokpa-Mosogar	Ethiope West	31	20
29	Irhodo Sec. Sch.	Irhodo-Jesse	Ethiope West	29	22
30	Mosogar Sec. Sch.	Mosogar	Ethiope West	21	29
31	Ogharefe Sec. Sch.	Oghara-Junction	Ethiope West	19	31
32	Ogini Gram. Sch.	Ogharefe	Ethiope West	33	17
33	Okunigho Sec. Sch.	Okunigho	Ethiope West	25	26
34	Onyobru Sec. Sch.	Onyobru	Ethiope West	23	27
35	Orefe Sec. School	Ogharefe	Ethiope West	24	26
36	Oreki Sec. Sch.	Oghareki	Ethiope West	21	29
37	Osoguo Sec. Sch.	Osoguo	Ethiope West	19	31
38	Ovade Sec. Sch.	Ovade	Ethiope West	22	29
39	Toborise Basic Sch.	Ebughweri	Ethiope West	31	19
40	Uduaka Sec. Sch.	Mosogar	Ethiope West	25	26
41	Udurhie Sec. Sch.	Mosogar	Ethiope West	31	20
42	Ugbenu Sec. Sch.	Ugbenu	Ethiope West	23	27
43	Ugbevwe Sec. Sch.	Ugbevwe	Ethiope West	24	26
44	Ukavbe Sec. Sch.	Otefe	Ethiope West	34	16

45	Ejera Sec. Sch.	Okono	Ethiope West	17	33
46	Oghareki Grammar School	Oghareki	Ethiope West	32	18
47	Jesse Secondary School	Jesse	Ethiope West	31	19
48	Ihwighwu Secondary School	Ijomi	Ethiope West	32	18
49	Osubi Sec. Sch.	Osubi	Okpe	20	30
50	Oyenke Sec. Sch.	Oyenke	Okpe	15	35
51	Adeje Sec. Sch.	Adeje	Okpe	25	27
52	Aghalokpe Mixed Sec. Sch.	Aghalokpe	Okpe	31	20
53	Arhagba Sec. Sch.	Arhagba	Okpe	30	20
54	Egborode Sec. Sch.	Egborode	Okpe	15	30
55	Eradajaye Sec. Sch.	Adagbrasa-Ugolo	Okpe	33	17
56	Esezi Sec. Sch.	Ughoton	Okpe	26	14
57	Jeddo Sec. Sch.	Jeddo	Okpe	25	25
58	Oha Sec. Sch.	Oha	Okpe	33	17
59	Okene Mixed Sec. Sch.	Okuokoko	Okpe	25	19
60	Okuovo Basic Sch.	Okuovo	Okpe	29	22
61	Orerokpe Sec. Sch.	Orerokpe	Okpe	31	30
62	Orhue Sec. Sch.	Mereje	Okpe	23	27
63	Oviri-Okpe Sec. Sch.	Oviri-Okpe	Okpe	17	33
64	Ugbokodo Sec. Sch.	Ugbokodo	Okpe	30	20
65	Adaka Gram. Sch.	Ugborhen	Sapele	24	11
66	Chude Girls Model Sec. Sch.	Sapele	Sapele	25	12
67	Elume Gram. Sch.	Elume	Sapele	13	27
68	Ethiope Mixed Sec. Sch.	Sapele	Sapele	22	38
69	Eziafa Sec. Sch.	Eziafa	Sapele	31	18
70	Gana Sec. Sch.	Sapele	Sapele	34	14
71	Ibada Seconadry Sch.	Ibada-Elume	Sapele	23	27

72	Ogiedi Mixed Sec. Sch.	Ogiedi-Elume	Sapele	13	28
73	Okotie-Eboh Gram. Sch.	Sapele	Sapele	35	14
74	Okpe Gram. Sch.	Sapele	Sapele	40	11
75	Orodje Gram. Sch.	Sapele	Sapele	23	27
76	Ozue Sec. Sch.	Okuovo Sapele	Sapele	31	20
77	Ufuoma Mixed Sec. Sch.	Sapele	Sapele	26	24
78	Urhiapele Mixed Sec. Sch.	Sapele	Sapele	23	27
79	Zik Sec. Sch.	Sapele	Sapele	32	20
80	Sapele Technical College	Sapele	Sapele	21	39
81	Okpaka Sec. Sch.	Okpakpa	Udu	13	27
82	Adadja Sec. Sch.	Emadadja	Udu	32	11
83	Aladja Sec. Sch.	Aladja	Udu	13	37
84	Egini Gram. Sch.	Egini	Udu	23	28
85	Ekete Sec. Sch.	Ekete	Udu	31	19
86	Ogbe-Udu Sec. Sch.	Ogbe-Udu	Udu	31	20
87	Oghior Sec. Sch.	Oghior	Udu	25	26
88	Oleri Sec. Sch.	Oleri	Udu	42	8
89	Orhuwhorun High Sch.	Orhuwhorun	Udu	32	10
90	Otor-Udu Sec. Sch.	Udu	Udu	21	29
91	Ovwian Sec. Sch.	Ovwian	Udu	17	17
92	Owhrode Mixed Sec. Sch.	Owhrode	Udu	24	34
93	Ubogo Sec. Sch.	Ubogo	Udu	22	31
94	Ujevwu Secondary Sch.	Ujevwu	Udu	32	18
95	Adagwe Sec. Sch.	Eruemukohwarien	Ughelli North	22	28
96	Afiesere Sec. Sch.	Afiesere	Ughelli North	23	27
97	Agadama Sec. Sch.	Agadama	Ughelli North	18	27
98	Aragba Sec. Sch.	Aragba-Orogun	Ughelli North	12	38
99	Awirhe Sec. Sch.	Awirhe-Agbarha	Ughelli North	23	27
100	Ebor Sec. Sch.	Ebor-Orogun	Ughelli North	21	30

101	Edjeba Sec. Sch.	Edjeba-Agbarha	Ughelli North	22	28
102	Edjekota Sec. Sch.	Edjekota	Ughelli North	12	28
103	Ehwerhe Gram. Sch.	Ehwerhe-Agbarho	Ughelli North	19	32
104	Ekiugbo Sec. Sch.	Ekiugbo	Ughelli North	35	17
105	Esejuvwewo Secondary School	Inene	Ughelli North	17	38
106	Oviri-Ogor Sec. Sch.	Oviri-Ogor	Ughelli North	28	18
107	Model Secondary School	Ughelli	Ughelli North	18	25
108	Ekredjebor Sec. Sch.	Ekredjebor-Ughelli	Ughelli North	16	34
109	Ekruopia Sec. Sch.	Obodeti-Orogun	Ughelli North	20	31
110	Emeragha Sec. Sch.	Emeragha	Ughelli North	32	18
111	Emonu Comp. High Sch.	Emonu-Orogun	Ughelli North	29	31
112	Eni Gram. Sch.	Evwreni	Ughelli North	25	26
113	Erhavwen Basic Sch.	Ekrerhavwen	Ughelli North	26	14
114	Girls Model Sec. School	Evwreni	Ughelli North	31	25
115	Government College	Ughelli	Ughelli North	14	26
116	Ibru College	Agbarha-Otor	Ughelli North	22	30
117	Ikweghwu Sec. Sch.	Ikweghwu-Agbarho	Ughelli North	19	30
118	Imodje Sec. Sch.	Imodje-Orogun	Ughelli North	33	17
119	Ofuoma Sec. Sch.	Ofuoma	Ughelli North	31	20
120	Ogbovwan Sec. Sch.	Ogbovwan	Ughelli North	39	11
121	Ogharha Sec. Sch.	Ogharha-Agbarha	Ughelli North	26	33
122	Oguname Basic Sch.	Oguname-Agbarho	Ughelli North	23	37

123	Oharisi Sec. Sch.	Ughelli	Ughelli North	26	30
124	Omo Sec. Sch.	Ovara-Orogun	Ughelli North	28	22
125	Orhoerha Sec. Sch.	Ugono-Orogun	Ughelli North	25	31
126	Orogun Gram. Sch.	Orogun	Ughelli North	22	29
127	Oteri Sec. Sch.	Oteri	Ughelli North	29	33
128	Otovwodo Gram. Sch.	Ughelli	Ughelli North	23	37
129	Owevwe Sec. Sch.	Ovwevwe	Ughelli North	31	21
130	Unenurhie Sec. Sch.	Unenurhie	Ughelli North	29	30
131	Unity Model Sec. Sch.	Agbarho	Ughelli North	29	11
132	Uvwiama Sec. Sch.	Uvwiama-Agbarho	Ughelli North	18	22
133	Uwheru Gram. Sch.	Uwheru	Ughelli North	18	31
134	Omavovwe Sec. Sch.	Omavovwe-Agbarha	Ughelli North	29	27
135	Ogor Technical College	Otogor	Ughelli North	14	33
136	Ohoro Sec. Sch.	Ohoro-Uwheru	Ughelli North	23	31
137	Agbarho Grammar School	Agbarho	Ughelli North	29	11
138	Akperhe Sec. Sch.	Akperhe-Olomu	Ughelli South	37	9
139	Iwhreka Technical College	Iwhreka	Ughelli South	27	11
140	Ogele Secondary School	Iwhreka	Ughelli South	30	18
141	Assah Sec. School	Assah	Ughelli South	16	34
142	Arhavwarien Gram. Sch.	Arhavwarien	Ughelli South	19	29
143	Effurun-Otor Sec. Sch.	Effurun-Otor	Ughelli South	27	29
144	Egbo Sec. Sch.	Egbo-Uhurie	Ughelli South	17	34
145	Ewu Gram. Sch.	Ewu-Urhobo	Ughelli South	30	14

146	Gbaregolor Sec. Sch.	Gbaregolor	Ughelli South	12	38
147	Ofrukama Sec. Sch.	Ofrukama	Ughelli South	37	11
148	Oginibo Gram. Sch.	Oginibo	Ughelli South	29	22
149	Okparabe Sec. Sch.	Okparabe	Ughelli South	29	15
150	Okpare Sec. Sch.	Okpare	Ughelli South	14	33
151	Okuama Sec. Sch.	Okuama	Ughelli South	21	31
152	Olomu Sec. Sch.	Olomu	Ughelli South	28	27
153	Ophorigbala Sec. Sch.	Ophorigbala	Ughelli South	14	10
154	Orere Sec. Sch.	Orere	Ughelli South	15	19
155	Otokutu Sec. Sch.	Otokutu	Ughelli South	34	15
156	Otu-Jeremi Sec. Sch.	Otujeremi	Ughelli South	31	22
157	Oviri-Olomu Sec. Sch.	Oviri-Olomu	Ughelli South	18	39
158	Ovwor Sec. Sch.	Ovwor	Ughelli South	34	23
159	Owawha Sec. Sch.	Owawha	Ughelli South	32	19
160	Okwagbe Secondary School	Okwagbe	Ughelli South	38	12
161	Ughevwughe Sec. Sch.	Ughevwughe	Ughelli South	31	20
162	Ogbavweni Gram. School	Usiefrun	Ughelli South	41	10
163	Ekakpamre Gram. School	Ekakpamre	Ughelli South	37	11
164	Alegbon Sec. Sch.	Effurun	Uvwie	36	12
165	Army Day Sec. Sch. I	Effurun	Uvwie	36	13
166	Ebrumede Sec. Sch.	Ebrumede	Uvwie	25	29
167	Ekpan Sec. Sch.	Ekpan	Uvwie	34	17
168	Ekpan Basic Sch.	Ekpan	Uvwie	13	33
169	Iteregbi Sec. Sch.	Iteregbi	Uvwie	10	25

170	Ogbe Sec. Sch.	Effurun	Uvwie	39	18
171	Ohorhe Sec. Sch.	Ohorhe	Uvwie	36	11
172	Opete Sec. Sch.	Opete	Uvwie	30	11
173	Sedeco Basic Sch.	Enerhen	Uvwie	25	29
174	Ugbolokposo Sec. Sch.	Ugbolokposo	Uvwie	34	18
175	Ugbomro Sec. Sch.	Ugbomro	Uvwie	30	23
176	Ugborikoko Sec. Sch.	Ugborikoko	Uvwie	26	31
177	Urhobo Model College	Effurun	Uvwie	39	26
178	Abe I Sec. Sch.	Aruakpommah	Uvwie	12	38
179	Army Day Sec. Sch. II	Effurun	Uvwie	39	17

Appendix G

Total population of chemistry students and number of schools that made up the sample

Schools	Towns/Vilages	location	No of chemistry students	

			Female	Male	
Okpe Grammar School	Sapele	Urban	20	31	51
Ibada Secondary School	Ibada-Elume	Rural	23	27	50
Alegbon Secondary School	Effurun	Urban	29	20	49
Opete Secondary School	Opete	Rural	20	31	51
Oviorie Sec. Sch.	Oviorie	Rural	17	23	40
Oyenke Sec. Sch.	Oyenke	Rural	15	11	26
Agbarho Grammar School	Agbarho	Urban	29	11	40
Effurun-Otor Sec. Sch.	Effurun-Otor	Urban	27	29	56
Total					363

Note: schools located in villages are classified as rural schools and those located in towns are classified as urban schools based on availability of social amenities and infrastructural facilities.

Appendix H

Analysis Output

Research Question 1 and Hypothesis 1

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
posttest	cooperative method	201	58.59	12.499	.882	56.85	60.33	38	90
	lecture method	162	47.40	11.917	.936	45.55	49.24	14	70
	Total	363	53.59	13.436	.705	52.21	54.98	14	90
pretest	cooperative method	201	22.13	9.493	.670	20.81	23.45	6	44
	lecture method	162	20.65	8.952	.703	19.27	22.04	2	44
	Total	363	21.47	9.272	.487	20.51	22.43	2	44

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
posttest	.000	1	361	.989
pretest	.218	1	361	.641

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
posttest	Between Groups	11236.216	1	11236.216	74.961	.000
	Within Groups	54111.442	361	149.893		
	Total	65347.658	362			
pretest	Between Groups	195.167	1	195.167	2.278	.132
	Within Groups	30927.279	361	85.671		
	Total	31122.446	362			

Research Question 2 and Hypothesis 2

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
pretestcoopfemale	92	6	44	21.96	9.802
pretestlectfemale	88	2	44	20.27	9.209
posttestcoopfemale	92	38	90	57.22	11.897
posttestlectfemale	88	14	68	45.98	12.831
Valid N (listwise)	88				

T-Test

Group Statistics

	femcooplect	N	Mean	Std. Deviation	Std. Error Mean
posttestfemale	cooperative method	92	57.22	11.897	1.240
	lecture method	88	45.98	12.831	1.368

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
posttestfemale	Equal variances assumed	2.063	.153	6.098	178	.000	11.240	1.843	7.603	14.878
	Equal variances not assumed			6.087	175.472	.000	11.240	1.846	7.596	14.884

Research Question 3 and Hypothesis 3

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
pretestcoopmale	109	6	44	22.28	9.267
pretestlectmale	74	4	42	21.11	8.678
posttestcoopmale	109	40	90	59.74	12.927
posttestlectmale	74	22	70	49.08	10.568
Valid N (listwise)	74				

T-Test

Group Statistics

	malecooplecture	N	Mean	Std. Deviation	Std. Error Mean
posttestmale	cooperative method	109	59.74	12.927	1.238
	lecture method	74	49.08	10.568	1.229

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
posttestmale	Equal variances assumed	2.848	.093	5.883	181	.000	10.662	1.812	7.086	14.238
	Equal variances not assumed			6.113	174.751	.000	10.662	1.744	7.219	14.105

Research Question 4 and Hypothesis 4

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
pretesturbcoop	100	6	44	22.04	9.644
posttesturbcoop	100	40	90	60.44	13.029
pretestrurcoop	101	6	44	22.22	9.389
posttestrurcoop	101	38	88	56.75	11.730
Valid N (listwise)	100				

T-Test

Group Statistics

	locurbanrur	N	Mean	Std. Deviation	Std. Error Mean
posttestcoop	urban	100	60.44	13.153	1.315
	rural	101	56.75	11.730	1.167

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
posttestcoop	Equal variances assumed	1.308	.254	2.007	199	.046	3.528	1.758	.062	6.993
	Equal variances not assumed			2.006	195.987	.046	3.528	1.759	.059	6.996

Research Question 5 and Hypothesis 5

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
preurbmalecoop	51	8	44	23.45	8.855
posturbmalecoop	51	42	90	62.75	13.988
preurbfemcoop	49	6	42	20.57	10.288
posturbfemcoop	49	40	90	58.04	11.608
Valid N (listwise)	49				

T-Test

Group Statistics

	sexurbancoop	N	Mean	Std. Deviation	Std. Error Mean
posttesturbcoop	male	51	62.71	13.987	1.827
	female	49	58.04	11.605	1.909

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
posttesturbcoop	Equal variances assumed	.067	.796	.141	97	.888	.373	2.641	-4.869	5.614
	Equal variances not assumed			.141	96.461	.888	.373	2.642	-4.872	5.617

Research Question 6 and Hypothesis 6

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
prerurmalecoop	58	6	42	21.24	9.572
postrurmalecoop	58	40	88	57.10	11.395
prerurfemcoop	43	8	44	23.53	9.080
postrurfemcoop	43	38	88	56.28	12.287
Valid N (listwise)	43				

T-Test

Group Statistics

	sexrurcoop	N	Mean	Std. Deviation	Std. Error Mean
posttestrurcoop	male	58	57.10	11.395	1.513
	female	43	56.28	12.287	1.875

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
posttestrurcoop	Equal variances assumed	.005	.944	.921	98	.359	2.200	2.388	-2.539	6.940
	Equal variances not assumed			.913	85.636	.364	2.200	2.409	-2.589	6.990

Research Question 7 and Hypothesis 7

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Pretestcoopmale	109	6	44	22.28	9.267
Pretestcoopfe	92	6	44	21.96	9.802
Posttestcoopmale	109	40	90	59.74	12.927
Posttestcoopfem	92	38	90	57.22	11.897
Pretestlectmale	74	4	42	21.11	8.678
Pretestlectfemale	88	2	44	20.27	9.209
Posttestlectmale	74	22	70	49.08	10.568
Posttestlectfemale	88	14	68	45.98	12.831
Valid N (listwise)	74				

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
teachingmethods	1	cooperative method	201
	2	lecture method	162
sex	1	male	183
	2	female	180

Descriptive Statistics

Dependent Variable: posttest

teachingmethods	sex	Mean	Std. Deviation	N
cooperative method	male	59.74	12.927	109
	female	57.22	11.897	92
	Total	58.59	12.499	201
lecture method	male	49.08	10.568	74
	female	45.98	12.831	88
	Total	47.40	11.917	162
Total	male	55.43	13.096	183
	female	51.72	13.554	180
	Total	53.59	13.436	363

Levene's Test of Equality of Error Variances[a]

Dependent Variable: posttest

F	df1	df2	Sig.
.942	3	359	.421

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + pretest + methods + sex + methods * sex

Tests of Between-Subjects Effects

Dependent Variable: posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25035.195[a]	4	6258.799	55.582	.000
Intercept	86561.142	1	86561.142	768.717	.000
pretest	13093.464	1	13093.464	116.278	.000
methods	8893.595	1	8893.595	78.981	.000
sex	529.243	1	529.243	4.700	.031
methods * sex	1.300	1	1.300	.012	.914
Error	40312.463	358	112.605		
Total	1107932.000	363			
Corrected Total	65347.658	362			

a. R Squared = .383 (Adjusted R Squared = .376)

Lack of Fit Tests

Dependent Variable: posttest

Source	Sum of Squares	df	Mean Square	F	Sig.
Lack of Fit	10925.552	67	163.068	1.615	.004
Pure Error	29386.912	291	100.986		

Estimated Marginal Means

1. teachingmethods

Dependent Variable: posttest

teachingmethods	Mean	Std. Error	95% Confidence Interval

			Lower Bound	Upper Bound
cooperative method	58.060[a]	.752	56.581	59.540
lecture method	48.037[a]	.838	46.389	49.686

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.

2. sex

Dependent Variable: posttest

sex	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
male	54.268[a]	.799	52.697	55.840
female	51.829[a]	.791	50.273	53.386

a. Covariates appearing in the model are evaluated at the following values:
pretest = 21.47.

3. teachingmethods * sex

Dependent Variable: posttest

teachingmethods	sex	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
cooperative method	male	59.220[a]	1.018	57.218	61.221
	female	56.901[a]	1.107	54.725	59.078
lecture method	male	49.317[a]	1.234	46.891	51.744
	female	46.757[a]	1.134	44.528	48.987

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.

Research Question 8 and Hypothesis 8

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
pretesturbcoop	100	6	44	22.04	9.644
posttesturbcoop	100	40	90	60.44	13.029
pretestrurcoop	101	6	44	22.22	9.389
posttestrurcoop	101	38	88	56.75	11.730
pretestlecturb	96	4	38	20.50	8.431
posttestlecturb	96	18	68	48.65	10.696
pretestlectrur	66	2	44	20.88	9.723
posttestlectrur	66	14	70	45.58	13.375
Valid N (listwise)	66				

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
teachingmethods	1	cooperative method	201
	2	lecture method	162
location	1	urban	196
	2	rural	167

Descriptive Statistics

Dependent Variable: posttest

teachingmethods	location	Mean	Std. Deviation	N
cooperative method	urban	60.44	13.029	100
	rural	56.75	11.730	101
	Total	58.59	12.499	201
lecture method	urban	48.65	10.696	96
	rural	45.58	13.375	66
	Total	47.40	11.917	162
Total	urban	54.66	13.299	196
	rural	52.34	13.527	167
	Total	53.59	13.436	363

Levene's Test of Equality of Error Variances[a]

Dependent Variable: posttest

F	df1	df2	Sig.

2.353	3	359	.072

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + pretest + methods + location + methods * location

Tests of Between-Subjects Effects

Dependent Variable: posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25662.093[a]	4	6415.523	57.874	.000
Intercept	85101.573	1	85101.573	767.694	.000
pretest	13373.966	1	13373.966	120.645	.000
methods	9713.260	1	9713.260	87.622	.000
location	1115.821	1	1115.821	10.066	.002
methods * location	5.179	1	5.179	.047	.829
Error	39685.565	358	110.854		
Total	1107932.000	363			
Corrected Total	65347.658	362			

a. R Squared = .393 (Adjusted R Squared = .386)

Lack of Fit Tests

Dependent Variable: posttest

Source	Sum of Squares	df	Mean Square	F	Sig.
Lack of Fit	9705.805	68	142.732	1.381	.037
Pure Error	29979.760	290	103.378		

Estimated Marginal Means

teachingmethods

Dependent Variable: posttest

teachingmethods	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
cooperative method	58.164[a]	.744	56.701	59.626
lecture method	47.625[a]	.843	45.967	49.283

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
teachingmethods	1	cooperative method	201
	2	lecture method	162
location	1	Urban	196
	2	Rural	167
sex	1	Male	183
	2	Female	180

Descriptive Statistics

Dependent Variable: posttest

teachingmethods	location	Sex	Mean	Std. Deviation	N

cooperative method	urban	Male	62.75	13.988	51
		Female	58.04	11.608	49
		Total	60.44	13.029	100
	rural	Male	57.10	11.395	58
		Female	56.28	12.287	43
		Total	56.75	11.730	101
	Total	Male	59.74	12.927	109
		Female	57.22	11.897	92
		Total	58.59	12.499	201
lecture method	urban	Male	48.75	9.089	40
		Female	48.57	11.790	56
		Total	48.65	10.696	96
	rural	Male	49.47	12.213	34
		Female	41.44	13.491	32
		Total	45.58	13.375	66
	Total	Male	49.08	10.568	74
		female	45.98	12.831	88
		Total	47.40	11.917	162
Total	urban	male	56.59	13.903	91
		female	52.99	12.579	105
		Total	54.66	13.299	196
	rural	male	54.28	12.213	92
		female	49.95	14.715	75
		Total	52.34	13.527	167
	Total	male	55.43	13.096	183
		female	51.72	13.554	180
		Total	53.59	13.436	363

Levene's Test of Equality of Error Variances[a]

Dependent Variable: posttest

F	df1	df2	Sig.
1.584	7	355	.139

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + pretest + methods + location + sex + methods * location + methods * sex + location * sex + methods * location * sex

Tests of Between-Subjects Effects

Dependent Variable: posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26374.336[a]	8	3296.792	29.945	.000
Intercept	83616.122	1	83616.122	759.497	.000
pretest	12451.873	1	12451.873	113.102	.000
methods	9333.449	1	9333.449	84.777	.000
location	1218.901	1	1218.901	11.071	.001
sex	697.367	1	697.367	6.334	.012
methods * location	3.474	1	3.474	.032	.859
methods * sex	5.904	1	5.904	.054	.817
location * sex	14.634	1	14.634	.133	.716
methods * location * sex	38.720	1	38.720	.352	.554
Error	38973.322	354	110.094		
Total	1107932.000	363			
Corrected Total	65347.658	362			

a. R Squared = .404 (Adjusted R Squared = .390)

Lack of Fit Tests

Dependent Variable: posttest

Source	Sum of Squares	df	Mean Square	F	Sig.
Lack of Fit	15894.751	116	137.024	1.413	.013
Pure Error	23078.571	238	96.969		

Estimated Marginal Means

1. teachingmethods

Dependent Variable: posttest

teachingmethods	Mean	Std. Error	95% Confidence Interval

			Lower Bound	Upper Bound
cooperative method	58.071[a]	.746	56.605	59.538
lecture method	47.668[a]	.846	46.004	49.332

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.

2. location

Dependent Variable: posttest

location	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
urban	54.742[a]	.755	53.257	56.228
rural	50.997[a]	.834	49.356	52.638

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.

3. sex

Dependent Variable: posttest

sex	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
male	54.287[a]	.793	52.728	55.846
female	51.452[a]	.800	49.879	53.025

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.

4. teachingmethods * location

Dependent Variable: posttest

teachingmethods	location	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
cooperative method	urban	60.044[a]	1.050	57.979	62.109
	rural	56.099[a]	1.057	54.019	58.178
lecture method	urban	49.441[a]	1.089	47.300	51.581
	rural	45.895[a]	1.293	43.353	48.438

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.

5. teachingmethods * sex

Dependent Variable: posttest

teachingmethods	sex	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
cooperative method	male	59.359[a]	1.008	57.375	61.342
	female	56.784[a]	1.097	54.627	58.941
lecture method	male	49.216[a]	1.224	46.809	51.623
	female	46.120[a]	1.167	43.824	48.415

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.

6. location * sex

Dependent Variable: posttest

location	sex	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
urban	male	55.955[a]	1.108	53.775	58.134
	female	53.530[a]	1.026	51.511	55.549
rural	male	52.620[a]	1.135	50.388	54.852
	female	49.374[a]	1.226	46.963	51.784

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.

7. teachingmethods * location * sex

Dependent Variable: posttest

teachingmethods	location	sex	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
cooperative method	urban	male	61.466[a]	1.474	58.566	64.365
		female	58.622[a]	1.500	55.672	61.572
	rural	male	57.252[a]	1.378	54.542	59.962
		female	54.945[a]	1.605	51.789	58.102
lecture method	urban	male	50.444[a]	1.667	47.166	53.722
		female	48.437[a]	1.402	45.680	51.195
	rural	male	47.988[a]	1.805	44.439	51.538
		female	43.802[a]	1.868	40.128	47.476

a. Covariates appearing in the model are evaluated at the following values: pretest = 21.47.