EFFECTS OF CONCEPT- MAPPING STRATEGY ON REFLECTIVE THINKING AND ACADEMIC PERFORMANCE IN MOLE CONCEPT AMONG SECONDARY SCHOOL CHEMISTRY STUDENTS, KADUNA STATE, NIGERIA

BY

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

DEPARTMENT OF SCIENCE EDUCATION
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ZARIA

December,2016

DECLARATION

This dissertation entitled **"Effects of Concept- Mapping Strategy on Reflective Thinking and Academic Performance in Mole Concept Among Secondary School Chemistry Students,Kaduna State, Nigeria"**has been carried out by me in the Department of Science Education, Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. This dissertation was never presented for another degree or diploma at this or any other institution.

Nazeefah Ohunene, YAKUBU	**Signature**	**Date**

CERTIFICATION

This dissertation entitled "EFFECTS OF CONCEPT-MAPPING STRATEGY ON REFLECTIVE THINKING AND ACADEMIC PERFORMANCE IN MOLE CONCEPT AMONG SECONDARY SCHOOL CHEMISTRY STUDENTS IN KADUNA STATE, NIGERIA"by Nazeefah Ohunene YAKUBU with registration number MED/EDUC/36920/2012-2013 meets the regulation governing the award of M.ED in Science Education of Ahmadu Bello University, Zaria and is approved for contribution to knowledge and literary presentation.

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DEDICATION

This research study is dedicated to my parent Mallam Y.O. Shuaibu and Mrs. Z.A. Yakubu for their sacrifice throughout my studies.

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ABBREVIATIONS

The following abbreviations were used in this work. They include:

FRN Federal Republic of Nigeria

MCCT Mole Concept Construction Test

NECO National Examinations Council

NPE National Policy on Education

PPMC Pearson Product Moment Correlation

RTQ Reflective Thinking Questionnaire

MCPT Mole Concept Performance Test

SSCE Secondary School Certificate Examination

STAN Science Teachers Association of Nigeria

WAEC West African Examinations Council

WASSCE West African Senior Secondary School Certificate Examination

OPERATIONAL DEFINITION OF TERMS

Reflective Thinking: It is a process in which an individual actively, consistently andcarefully analyze and evaluate situation when relating it to ones' previous knowledge.

Concept –Mapping: It is a diagrammatical representation of concepts connected by alinking word to represent relationship between pairs of concepts.

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ABSTRACT

The study investigated the effects of concept -mapping strategy on reflective thinking and academic performance in mole concept among secondary school students in Kaduna state, Nigeria. A total of seventy six (76) SS2 students from two public schools in Giwa education zone were randomly selected from a population of six hundred and forty three (643) SS2 science students using balloting technique. This study adopted pre-test, post-test quasi-experimental-control group designs. Two groups were formed: The Experimental and the Control group. The experimental group students were taught Mole concept using concept-mapping strategy while the control group students were taught the same concept using lecture method. The instruments used for data collection were Mole Concept Performance Test (MCPT), Reflective Thinking Questionnaire (RTQ) and Mole Concept Construction Test (MCCT).The instruments were validated by both chemistry teachers and lecturers in Science Education Department.The Reliability coefficient of MCPT and RTQ were 0.89 and (0.59-0.81) respectively. Pearson Product Moment Correlation was used to determine the reliability coefficient of MCPT,while Cronbach Alpha was used to determine the reliability coefficient of RTQ. Based on the objectives, this study was guided by six research questions and answered using descriptive statistics. Six (6) null hypotheses stated were tested at 0.05 level of significance using statistical t-test, Spearman Rank Correlation (Rho) and Mann-Whitney U test. The results obtained from data analysis showed that students in experimental group performed significantly better than those in control group in both academic performance and level of reflective thinking. Also, there was a significant relationship between the academic performance and reflective thinking of students when taught using concept mapping strategy. Based on the findings of this study it is recommended among others that chemistry teachers should be trained and encouraged by Science Teachers Association of Nigeria to use concept-mapping strategy in teaching chemistry.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

The advancement made in science and technology has become a global phenomenon, science now permeates almost all facets of human endeavour. Nations are increasingly investing enormous resources into science for development and global competitiveness. Consequently, scientists and science educationists are today more recognized as playing crucial roles in advancement (Sunday, 2013). At the classroom level, the science teachers role in fostering students active involvement in doing and learning of science, is seen as crucial for students achievement in science (Adesoji,Ige, Iroesbu&Olagunju, 2003).As a result of the relevance of science and technology in nation building, the National Policy on Education (FME, 2004) emphasises on the teaching of science and technology in all institutions.

Chemistry is one of the science subjects taught in Nigeria Secondary Schools. Chemistry is commonly regarded as the 'Central science' or the "Mother of all science" (Ahiakwo, 2000). Okeke and Ezekannagba (2000) defined chemistry as a branch of science that deals with composition and change of matter. Chemistry could also be defined as the branch of science that deals with structure, composition and properties of matter. The relevance of Chemistry as a requirement for technological advancement of a Nation cannot be underrated. The classification of any Nation into developed, developing and under-developed could be measured accurately by the number of Chemists, Physicists, Engineers, Pharmacists, Doctors, Agriculturist and Science Educators the Nation could produce.

In spite of the central and important position of chemistry among other science and related disciplines, studies revealed that, academic performance of students in chemistry at

Senior Secondary School Certificate Examination (SSCE) has consistently been very poor and unimpressive (Njoku, 2005). Many factors have been implicated as contributing to this poor performance of students in chemistry in particular and science in general. Most of these factors include; Inadequate laboratory infrastructures and equipment in Chemistry, Lack of understanding of the nature and epistemological bases of Science Concept (Eniayeju, 2001), Poor teaching method, Lack of adequate practical equipment, Mathematical nature of Chemistry Concepts and Laws (Ajogu, 2001).

Academic Performance is the level of individuals' growth in a test when compared with the scores of others at the same level (Achino, 2002). The West African Examination Council (WAEC) and National Examination Council (NECO) lamented the poor students' performance in public examinations (Oranu, 2012). Report of June 2009 NECO examination showed that out of 1,1376,906 candidates only 24.9%, 44.17%, 30.4% and 37% obtained credit and above in Mathematics, Biology, Physics and Chemistry respectively (Mosadomi, 2010).The 2012 NECO result report still revealed a low credit rates for Physics (26%) and Chemistry (30.17%)(Nigeria Technology Guide, n.d).See Table 1.1

Table 1.1 shows the trend of Students performance in Chemistry at SSCE level (WAEC) from 2006 to 2015 in Nigeria.

Year	Number of Students Examined	% Passes at Credit Level (Grades A1-C6)	% Failure (Grades D7-F9)
2006	380,104	44.90	55.10
2007	422,681	45.96	54.04
2008	418,423	44.42	55.57
2009	468,546	43.74	56.26
2010	465,643	50.72	49.28
2011	349,936	30.94	69.06
2012	352,242	30.95	69.05
2013	432,230	35.96	64.04
2014	428,513	34.44	65.56
2015	442,091	35.97	64.03

Table 1.1:Trends of performance in Chemistry in the West African Senior School CertificateExamination May/June 2006-2015

Source: WAEC Office (2006-2015)

FromTable 1.1, the trends of students failure in chemistry between 2006 to 2010 is within the range of (49-55)% while between 2011 to 2015 the failure increased to 69%.This indicates that that over the years in chemistry, the academic performance of students in WAEC has declined. Many factors might have contributed to this consistent failure.

The teaching methods employed for the teaching and learning of chemistry at the Senior Secondary School level has little or no positive effect on Students' academic performance in

Chemistry. This is because majority of science teacher still teach students using the lecture method. Science educators such as Danjuma (2005) reported that about 80%-90% of the scientific information or principles students received from their teachers are through lecture method. Eniayeju (2001) also pointed out that the use of concrete materials facilitates better and proper understanding of chemistry concepts. . This is because chemistry concepts are abstract and can best be taught using activity base method which is 'Hands on' 'minds on' (Olorukooba, 2012).A number of activity-oriented instructional strategies have been advocated for by curriculum designers and Science educators to help improve on the failure rate among Secondary School Science Students (Eniayeju, 2001). Examples of these strategies include guided discovery approach, demonstration method, discussion method, concept mapping and problem-solving for teaching chemistry at senior secondary schools stipulated in National Policy on Education (FME, 2004).

Concept mapping is an educational tool that is used to facilitate and demonstrate students comprehension through the use of visual medium (Bienstein,).Concept maps are two or three-dimensional spatial or graphical displays that make use of labeled nodes to represent relationship between pairs of Concepts (Bamidele, Adetunji, Awodele&Irinoye,2013). Concept maps have been found to be a useful classroom tools for observing nuances of meaning, helping students organize their thinking and summarizing subjects of study(Canas, Hill, Granados & Perez, 2003). From an educational perspective, a growing body of research indicates that the use of concept maps could facilitate meaningful learning (Canas, Hill, Craft, Suri, & Lott, 2004). Concept mapping teaching strategy have been found to enhance learning in the following manners as scaffold for understanding, for consolidation of educational experiences, to improve affective conditions for learning, as an aid or alternative to traditional writing and as a mediating representation(Canas, *et al*, 2003).Concept Mapping serves as a strategy to help learners organize their cognitive frameworks into more powerful integrated patterns (Kinchin, 2005).Novak and Gowin noted that the act of mapping is a creative activity, in which the learner must exert effort to clarify meanings, by identifying important concepts, relationships, and structure within a specified domain of knowledge. The activity fosters reflection on one's knowledge and understanding, providing a kind of feedback that helps students monitor their learning and, perhaps with assistance of teachers or peers, focus attention on learning needs. Concept mapping is activity oriented, which involves students to think reflectively when linking concepts together to give meaning.

The term Reflective thinking may be credited to the work of Dewey (1933),who defined it as active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the ground that supports it and the conclusion to which it tends.Reflective Thinking can therefore be seen as an ability of an individual to think actively, consistently and carefully when relating a situation to once previous knowledge. Various strategies have been used to promoste reflective thinking, these include blogging, use of self-monitory techniques and concept maps (Shama& Xie,2011). In educational psychology research interest has emerged in the study of reflective thinking as possible antecedent of future academic achievement (Phan,2007 &2008).Leung and Kember (2003) based on Mezirow's theoretical framework advocated that reflective thinking may be categorized into four distinct phases; in their order of importance-habitual action, understanding, reflection and Critical reflection.

- Habitual action is a mechanical and automatic activity that is performed with little conscious thought.
- Understanding is learning and reading without relating to other situations.

- Reflection concerns active, persistent and careful considerations of any assumption or belief grounded in our consciousness.
- Critical Reflection is considered as higher level of reflective thinking that involve us to become more aware of why we perceive things, the way we feel, act and do things.

Research has shown that in general the four phases of reflective thinking make a contribution to the prediction of academic achievement. For example, habitual action and understanding are related negatively with academic achievement (Phan,2007&2008) .Whereas reflection and critical reflection positively predict academic achievement (Phan, 2008).It is in view of this , the study investigated the relationship between student's reflective thinking and academic performance when taught mole concept using concept- mapping strategy.

Mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon – 12. Its symbol is mol. Mole Concept is a difficult Concept in Chemistry, as a result of its difficult to comprehend; students dislike topics in chemistry that require the use or application of Mole Concept to solve. The findings of Jimoh (2004), Dun and Anthony (2003) has proven thattopics like Electrolysis, Balanced Chemical Equation, Redox Equations, Stoichiometry and Quantitative analysis are difficult for students to comprehend. Also according to Bamidele, Adetunji, Awodele and Irinoye (2013) Stated that the Students were observed to be deficient in the use of the Mole Concept and its application to Stoichiometry.

Stoichiometry is a branch of chemistry that expresses the mole ratio between the reactants and products of a chemical reaction. It lies at the core of quantitative chemistry, whether in the form of gravimetric analysis or volumetric analysis. Stoichiometry is simply the mathematics behind chemistry. Given enough information, one can use stoichiometry to calculate masses, moles and percent within a chemical equation. Determination of what and how much is used and produced in chemical processes is the major concern of stoichiometry and can only be achieved by the knowledge of Mole Concept. The researcher intends to teach stoichiometry since it employs the knowledge of mole concept in solving problems.

The term gender is socio-cultural and is built based on the biological expectations of the individual on the basis of being a male or female (Peter & Samuel, 2013). Gender, then, refers to a set of assumptions about the nature and character of biological differences between males and females, assumptions that manifest in a number of ideas and practices that have a determinant influence on identity, social opportunities and life experiences of human actors (Taylor,1999). Many scholars have researched into gender differences in academic achievement especially in sciences and mathematics. Many have found that male students performed better than their female counterparts (Oyedeji,1996; Ayedun.2000; Etukudo, 2002 & Kolawole2002). But, a few scholars have also found no significant difference in academic performance in science and mathematics between male and female students (Ogunkola&Owolabi 2000 &Kurumeh, 2004). The controversy as to which of the sexes would have better academic performance therefore, continues. However, the census figure of 1999 revealed that about 48% of Nigeria's total population is female. This figure is significant towards the development of any nation,therefore, it cannot be neglected. It was based on this, that the study investigated the effects of concept mapping teaching strategy on reflective thinking and academic performance in mole concept among secondary school chemistry students and also whether concept mapping teaching strategy is gender related or not

1.1.1 Theoretical Framework

Concept mapping is rooted in Ausubsel's Assimilation Theory (Ausubel, Novak &Hanesian, 1978). Assimilation theory posits that new knowledge can be learned most effectively by relating it to previously existing knowledge. Concept maps may be viewed as a methodological tool of assimilation theory that displays fundamental elements of the theory such as subsumption, integrative reconciliation and progressive differentiation. Concept maps allow for the representation of non-hierarchical relationships or cross-links, as well as other types of non-hierarchical arrangements.

Ausubel (1963) proposed how meaningful verbal learning and retention can be facilitated through the use of extrinsic organizing devices that modify the learner's cognitive structure. He stressed that if existing cognitive structure is clear, stable and suitably organized, it facilitates the learning and retention of new subject matter.

However, if it is unstable, ambiguous, disorganized or chaotically organized, it inhibits learning and retention. In order to describe the importance of classification in learning and retention and the strategy for deliberately manipulating cognitive structure so as to enhance proactive facilitation and to minimize proactive interference, Ausubel (1963) coined the phrase "advance organizer" which involves the use of approximately relevant and inclusive introductory materials that are maximally clear and stable. The organizer functions to 'bridge the gap' between what the learners already know and what he need to know before he can meaningfully learn the task at hand. Concept maps are usually introduced in advance of learning materials to facilitate the establishment of meaningful learning set. The central propositions in Ausubel's cognitive assimilation (subsumption) theory (Ausubel, 1968) which is the basis for concept mapping, is that;

1. Concepts derive their meaning through their inter-connections with other concepts and
2. Meaningful learning occurs when fresh knowledge is consciously anchored to relevant concept in the cognitive structure of the learner.

According to Wandersee (1990), concept mapping relates directly to such theoretical principles as prior knowledge, subsumption, progressive differentiation, cognitive bridging and integrative reconciliation. This theory involves the learners linking new specialized concepts to more generalized, more inclusive concepts in the learners' existing structure of knowledge (Schema) in which concept mapping stands to achieve. It is in view of this that the study is anchored on Ausubel's assimilation theory, the ability of Students to link new knowledge to the existing one through concept mapping.

1.2 Statement of the Problem

Poor performance in science has been of concern to educationists and researchers. In Nigeria and other developing countries, stakeholders in science education are interested in knowing the cause of the incessant poor performance in chemistry and whether it is in any way related to the teaching methods and teachers' factor. The chief examiner's report for the West African Senior School Certificate Examination (WASSCE 2010-2012) pointed out that some of the reasons for candidates poor performance in chemistry are; inability of the students to tackle most of the numerical questions; poor expressions and the use of nomenclature especially in organic compound and writing of formulae and incorrect balanced chemical equations. Dun (2005) and Anthony (2009) also pointed out that students have difficulties in learning certain chemical concept such as solubility, electrolysis, redox equation, chemical equilibrium and balancing of chemical equations.

Due to the importance placed on stoichiometry, the examination bodies such as WAEC and NECO always set examination questionsin practical chemistry and the theory part on stoichiometry, in which the knowledge of mole concept serve as the basis for tackling such questions (Bamidele*et al*, 2013). It is therefore necessary that students should master mole concept as it will help in better understanding of some chemistry topics, such as ;electrolysis, balancing of chemical equations, redox equation, stoichiometry and quantitative analysis.

In order to achieve effective mastering of mole concept and other difficult concepts in chemistry, several instructional strategies such as problem solving, cooperative learning, blog concept-mapping andinquiry methods are devised over the years. However, effective strategies designed to promote efficient and meaningful learning have been found to rely upon connecting prior knowledge to new concepts (Carol, 1998). Research studies have indicated that concept mapping is an example of such strategies (Novak &Canas, 2008).

According to Dewey (1933) reflective thinkers are problem solvers,Most scientists are reflective thinkers which make them problem solvers. The present society is challenged with a lot of problems which makes it necessary to promote reflective thinking among secondary school student, since students are part of the society, it is therefore necessary to determine students' level of reflective thinking. It is in line with all the stated problems above that the study investigated the effects of concept mapping teaching strategy on chemistry students' reflective thinking and academic achievement in mole concept among secondary schools in Giwa educational zone, Kaduna state.

1.3 Objectives of the Study

This study has the following objectives; to determine:

1. the effect of concept mapping strategy on chemistry students' academic performance in mole concept.
2. the effect of concept mapping strategy on chemistry students' reflective thinking.
3. whether there is relationship betweenstudents' academic performance and reflective thinking.
4. gender difference in academic performance when taught using concept mapping.
5. gender difference in reflective thinking when taught using concept mapping.
6. gender difference in concept map construction

1.4 Research Questions

This study was guided by the following research questions:

1. What is the difference between mean scores of chemistry students taught using concept mapping strategy and those taught using lecture method?
2. What is the difference instudents 'reflective thinking between those taught using concept mapping teaching strategy and those taught using lecture method?
3. What is the relationship between students' academic performance mean scores and reflective thinking mean rank when taught using concept mapping strategy?
4. What is the differencebetween the academic performance mean scores of male and female students exposed toconcept mapping strategy?
5. What is the difference between reflective thinking exhibited by male and female students taught using concept mapping teaching strategy?
6. What is the difference between male and female students' ability to construct a concept map?

1.5 Null Hypotheses

The following hypotheses were formulated to answer the research questions at 0.05level ofsignificance:

$H0_1$: There is no significant difference between the mean scores of students taught using concept mapping strategy and those taught using lecture method.

$H0_2$: There is no significant difference between reflective thinking mean rank of students taught using concept mapping strategy and those taught using lecture method.

$H0_3$: There is no significant relationship between mean scores and reflective thinking mean rank of students taught using concept mapping strategy.

$H0_4$: There is no significant difference between the mean scores of male and female students when taught using concept mapping strategy.

$H0_5$**:** There is no significant difference between the reflective thinking mean rank of male and femalestudents when taught using concept mapping strategy.

$H0_{6:}$ There is no significant difference between male and female students' ability to construct a concept map.

1.6 Significance of the Study

The findings of this study would help in improving chemistry education in the following ways;

The findings of the study would facilitate the improvement of science teaching and learning of chemistry in secondary school, by using suitable teaching method that require students to brain storm.Text book publishers may find the study useful to design activities that involve the use of concept mapping to aid meaningful learning among students. Curriculum planners may incorporate the use of concept mapping teaching strategy in chemistry curriculum.

The findings would assist the science teachers to know the effects of concept mapping strategy on students' reflective thinking and academic performance thereby adopting the method. Fellow researchers and professional bodies such as STAN may use outcome of the study to replicate it in the other study areas, improve on it or adapt it for similar studies. This study would add new information to the existing literature in chemistry education.

1.7 Scope of the Study

This research investigated the effects of concept mapping teaching strategy on reflective thinking and academic performance in mole concept among secondary school chemistry students in Kaduna state, Nigeria. The research was delimited to all the 14 public secondary schools in Giwa education zone. The choice of public school was made because the schools comprise of students with average academic performance, average age and financial status which makes them viable for the study. The study comprisedseventy six SS2 studentss with average age of 16years. The choice of seventy six students selected was viable for the study and is in line with the central limit theorem. The SS2 students were also selected purposively for the study, because the concept of Stoichiometry is in SS2 curriculum and reports have shown students failure in stoichiometry. The selected concepts taught were Molarity, MassConcentration, Molar mass, Amount, Avogadro's number, Atomic mass and Mass number, Chemical quantities and unit, Percentage of elements. The hierarchical type of concept mapping was used in this study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This study investigated the effects of concept mapping strategy on reflective thinking and academic performance in mole concept among secondary school chemistry students in Kaduna state, Nigeria. The purpose of this chapter was to review the studies that were related to the research and is presented with the following sub-headings:

- Chemistry as a Science Subject in Secondary School
- Stoichiometryand Mole Concept
- Science Teaching Methods
- Concept Mapping Teaching Strategy
- Origin of Concept Mapping
- Types of Concept Mapping
- Uses of Concept Mapping in Teaching and Learning of science
- Lecture Method of Teaching Science
- Concept of Reflective Thinking
- The Eight Steps of Reflective Thinking
- Why it is Necessary to Determine Students' Reflective Thinking
- Effects of Concept Mapping on Reflective Thinking
- Effects of Reflective Thinking on Academic Performance
- Academic Performance in Chemistry at Secondary School
- Factors Affecting Students' Academic Performance in Chemistry
- Gender and Academic Performance in Secondary school

- Overview of Similar Studies
- Implications of Literature Reviewed on the Present Study

2.2 Chemistry as a Science Subject in Secondary School

Ogunleye (2000)observed that science is a dynamic human activity concerned with understanding the workings of our world. This understanding helps man to know more about the universe. Chemistry is one of the Science subjects taught in Nigeria Secondary Schools. Chemistry is commonly regarded as the ‘Central Science’ or the “Mother of all Science” (Ahiakwo, 2000). Okeke and Ezekannagba (2000) defined chemistry as a branch of science that deals with composition and change of matter. Chemistry could also be defined as the branch of science that deals with structure, composition, properties and uses of anything that has mass and can occupy space. Since everything in the universe is a matter, we can therefore say that chemistry is the study of the universe. Chemistry as a science subject is taught to student from SS1 to SS3. Chemistry is an important science subject that occupies a prominent place in the school science curriculum.The chemistry syllabus covers the organic, inorganic and physical aspect of Chemistry. Due to its importance, it is necessary to use suitable methods in teaching student. The teaching methods employed for the teaching and learning of chemistry at the Senior Secondary School level has little or no positive effect on the Students’ academic performance in Chemistry. This is because majority of science teacher still teach students using the lecture method. .Science educators such as Danjuma (2005) reported that about 80%-90% of the scientific information or principles students received from their teachers are through lecture method.

A number of activity-oriented instructional strategies have been advocated for by curriculum designers and Science educators to help improve on the failure rate among Secondary School Science Students (Eniayeju, 2001). Examples of these strategies include guided discovery approach, demonstration method, discussion method, Concept mapping and problem-solving for teaching chemistry at senior secondary schools. Chemistry serves as a prerequisite to the study of medicine, pharmacy, agriculture, engineering, textile and clothing (Ayuba, 2014).In other word, Students are required to pass chemistry at credit level in order to qualify for admission into any tertiary institutions to study pure or applied science programmes.

2.2.1 The Concept of Stoichiometry

Stoichiometry is a branch of chemistry that deals with the quantitative relationships that exist between the reactants and products in chemical reactions. Determination of what and how much is used and produced in chemical processes is the major concern of stoichiometry. Stoichiometry is simply the mathematics behind chemistry. Given enough information, one can use stoichiometry to calculate masses, moles and percents within a chemical equation. It is a mathematical method to calculate quantitative information from chemical formulae or equation of chemical reaction.Every chemical reaction has its characteristic proportions. Chemical formulae,equations, atomic weights and molecular weights are used to find out these proportions.

In a balanced chemical reaction, the relations among quantities of reactantand products typically form a proportion of whole numbers. For example, in a reaction that formsammonia (NH_3), exactly one molecule of nitrogen (N_2) reacts with three molecules ofhydrogen (H_2) to produce two molecules of NH_3:$N_2 + 3H_2 \rightarrow 2NH_3$

Stoichiometry can be used to derive various kinds of information from the balanced chemical equation. Depending upon its use, it can be broadly classifies as reaction stoichiometry, composition stoichiometry, gas stoichiometry etc.

1. **Reaction Stoichiometry** describes the quantitative relationships among substances as they participate in chemical reactions. In the example above, reaction stoichiometry describes the 1:3:2 proportion s of molecules of nitrogen, hydrogen, and ammonia.
2. **Composition Stoichiometry** describes the quantitative (mass) relationships among elements in compounds. For example, composition stoichiometry describes the nitrogen to hydrogen (mass) relationship in the compound ammonia i.e. 28 grams of nitrogen react with 6 grams of hydrogen to form 34 grams of ammonia.

Stoichiometry can be used to calculate quantities such as the amount of products that can be produced with given reactants and percent yield (the percentage of the given reactant that is made into the product).

A stoichiometric amountof a reagent is the amount or ratio where, it is assumed that the reaction proceeds to completion and:

I. All reagents is consumed,

II. There is no shortfall of reagents, and

III. No residues remain.

3. **Gas Stoichiometry** deals with reactions involving gases, where the gases are at a known temperature, pressure, and volume and can be assumed to be ideal gases. For gases, the volume ratio is ideally the same by the ideal gas law, but the mass ratio of a single reaction has to be calculated from the molecular masses of the reactants and products. In practice, due to the existesnce of isotopes, molar masses are used instead when calculating the mass ratio.

Stoichiometry is based on the law of conservation of mass. The mass of the reactants equals the mass of the products.

2.2.2 The Mole Concept

In Latin, mole means ‘massive heap’ of material. In chemistry, it is a unit which isused to describe an amount of atoms, ions and molecules. It enables chemists to count these particles by weighing. According to 14th conference of National Institutes of Science and Technology (NIST) held in 1971 define mole as the amount of substance of a system which contains as many elementaryentities as there are atoms in 0.012 kilogram of carbon – 12. Its symbol is mol.When the mole is used, the elementary entities must be specified and they maybe atoms, molecules, ions, electrons, other particles or specified group of such particles.Visualizing a mole as a pile of particles, however, is just one way to understandthis concept. A sample of a substance has mass, volume (generally used with gases) and number of particles that is proportional to the chemical amount (measure in moles) of the sample. For example, one mole of oxygen (O_2) occupies a volume of 22.4 liters at Standard Temperature and Pressure (STP) has a mass of 31.998 grams and contains about 6.022×10^{23} atoms of oxygen. Measuring one of these quantities helps in the calculation of the others and this is frequently done in stoichiometry.

2.3 Methods of Teaching Science (Chemistry)

There are many methods and techniques for effective teaching. These different methods and techniques should be used skillfully in the class by the teachers in order to teach his students effectively. The skillful and competent teacher uses as many methods and techniques as possible because, there is no single method which is regarded as the best for every teaching situation. In a single lesson therefore, the teacher can employ as many methods as possible. The success or failure of any educational endeavour depends ultimately upon the method adopted by the teacher.

According to Vin-Mbah (2012) method can be defined as a practical application of teaching principles based on the nature of learner, the nature of the subject and the learning needs of the pupils/students (Vin-Mbah, 2012). These methods are usually those that have been tried or used by educationists and teachers in different parts of the world. They are:

Lecture method, learning by doing method, discovery method, the play method, The Socratic method, Co-operative method, the project method, The problem-solving method

The Dalton plan or assignment method, The remedial method, Play-way methodIndividual method, Dramatic method, demonstration method, Discussion method, Story-telling method, Concept mapping method,Computer Assisted Method.

Basically, teaching methods can generally be classified into two broad categories, namely:

- Child-centred methods
- Teacher-centred methods

Child-Centred Methods include: Activity methods, assignment supervised study, discussion method, field trip Project method, Play and games method etc.

The teacher centered methods as the name implies means that the principal actor in the lesson is the teacher while the learners are passive listeners. At the end of the lesson, the learner may ask one or two questions or be required to answer some questions or pass some comments or jot down some points.

Teacher-Centred methods: They are clear negation of the accepted view that learning is an active rather than a passive process that the best and most applicable learning is learning by doing. Lecture methods, questioning method and demonstration method are some of the teaching methods in this category.

2.4 Concept Mapping Strategy

Concept mapping is the technique used by individuals and groups to organize, represent, and visualize knowledge and ideas in graphical formats. . Concept map according to Novak and Gowin (1984) is a schematic device for representing a set of concept meanings embedded in a framework of propositions. It is a two-dimensional hierarchical diagram that illustrates the interconnection between and among individual concepts. To Jonassen (2000), a concept map is a visual representation of concepts and their interrelationship. It is used to develop a structured framework in order to plan or evaluate various types and sizes of projects. Sometimes called knowledge maps, the graphical technique is based on graphically describing topics within one concept and/or relationships found among different concepts (Canas& Novak,2008). Concept mapping is one of the constructivists methods used in teaching science in most Western countries and it has been proved to be robust and versatile (Novak &Canas, 2008). Novak and Canas (2008) further explained that Concept maps are graphical tools used for organizing and representing knowledge. This includes concepts, usually enclosed in circles or boxes of some type, and the relationship between concepts indicated by a connecting line linking to concepts. Words on the line referred to as linking words or linking phrases specify the relationship between the two concepts.

Concept maps are generally, but not always, created so they are read from the top downward. Some concept maps are simple designs that examine one central theme and only a few associated topics. Other concept maps contain complex structures that describe multiple themes and relationships. Concept mapping has been reported to provide a very effective strategy to help students learn meaningfully by making explicit the links between scientific concepts(Novak &Gowin, 1984 ;Adamczyk, Wilson & Williams, 1994; Fisher, Wandersee, & Moody, 2000). Concept mapping is a teaching strategy that most teachers employ knowingly or unknowingly when trying to explain a concept to students. Concept maps have been found to enhance learning in the following manner: as a scaffold for understanding; forconsolidation of educational experiences, to improve affective conditions for learning, as an aid or alternative to traditionalwriting, and as a mediating representation (Canas, et al, 2003). Concept mapping serves as a strategy to help learners organize their cognitive frameworks into more powerful integrated patterns (Kinchin, 2005).

2.4.1 Historical Background of Concept Mapping

The technique of concept mapping was first developed in the 1960s and 1970s by American educator and research scientist Joseph D. Novak (1930–) while at Cornell University, in Ithaca, New York. During this time, Novak, a professor of education and biological sciences, developed an effective way to strengthen the process for his students performing research. Novak discovered that representing thoughts visually often helped students to effectively associate ideas without being inconvenienced by writing them down in lengthy formats. Novak and his student found that they could represent newly learned information by first defining a concept, adding related topics, and linking similar ideas. Such an arrangement helped to organize research information and formulate educational theses.

Novak’s work was based on the cognitive learning theory first developed by educational psychologist David Ausubel in the 1960s. Also known as the theory of meaningful learning and assimilation theory, Ausubel’s theory became a tool for structuring information in an easy-to-recognize way. He found that students learned new material based on prior knowledge. According to Ausubel, by visualizing past knowledge, students were better able to control the learning process and, consequently, learned new information faster and more efficiently.

The concept map itself is founded in a learning theory called constructivism, which states that humans learn from previously acquired knowledge. Swiss developmental psychologist Jean Piaget (1896–1980) is generally recognized as the first scientist to formalize constructivism into scientific structure.out of the necessity to find a better way to represent children's conceptual understanding, utilized Ausubel's cognitive theory to craft the idea of concept mapping.(Novak ,1977). Later, the theory of concept mapping developed by Novak, and first published in 1977, helped to guide educational research and instruction. Since that time, concept mapping has been widely applied to science, education, business, and government.

2.4.2 Components of Concept Maps

There are several components used when teaching and applying concept mapping. The concept map is generally represented in a defined order, with members arranging parts of the concept map according to a pre-determined ranking. The more general concepts are usually positioned at the top, and the more specific concepts, along with examples, images, and other describers, placed underneath. Networks are drawn, consisting of *nodes* usually enclosed in boxes but also represented by points, circles, or other figures. Nodes represent various concepts, with a concept defined as a perceived regularity in, or record of, some event or object.

Nodes are joined together with *connecting lines*, or links, which represent a particular relationship between two concepts. Nodes are always labeled, while links are usually labeled. Links can be nondirectional (with no arrows), unidirectional (with an arrow at one end), or bidirectional (with an arrow at both ends).

Linking words, phrases, and symbols are used to demonstrate the relationship or connection between concepts. Besides words and phrases, symbols such as +, -, and = are sometimes used. A *proposition* is the term used when two or more concepts are connected with linking lines and linking words, phrases, or symbols to form a meaningful statement. *Cross-links* are long connections, which consist of connecting lines with linking words, phrases, and symbols, between concepts in different themes (domains) of the concept map. Cross-links are usually used to help identify how various domains are related.

2.4.3 Types of Concept Mapping

According to the University of Illinois, US (2002), there are seven kinds of concept map. The most commonlyused five kinds of concept maps in chemistry are mentioned below with examples.

1. A Spider concept map is a kind of map that is used to investigate and enumerate various aspects of a single theme or topic. It helps student to organize their thoughts. Outwardly radiating sub-themes surround the center of the map. It looks a bit like a spider's web, as its name suggests.

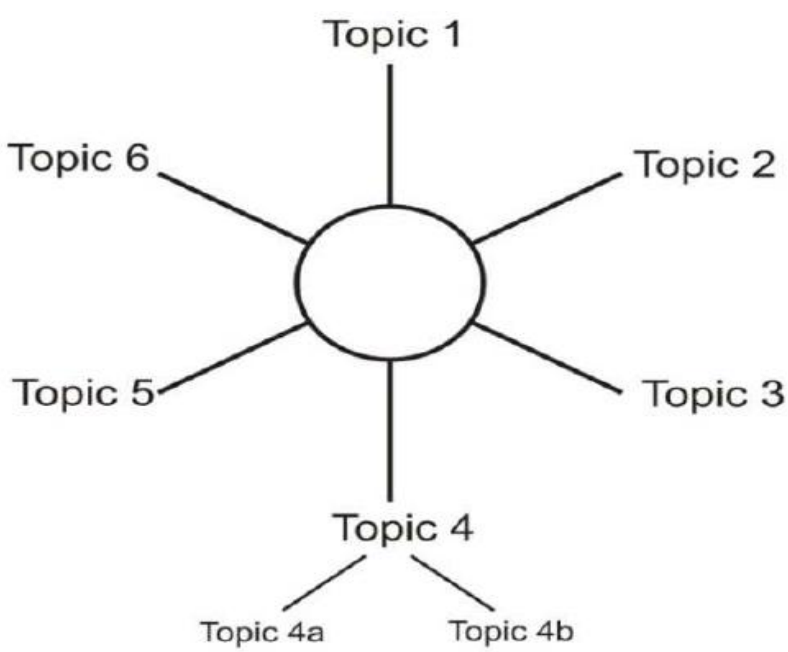

Figure 2.1a: Spider Concept Map

Source: Novak and Gowin (1984)

Example: The figure 2.1b is an example of a spider type of concept map

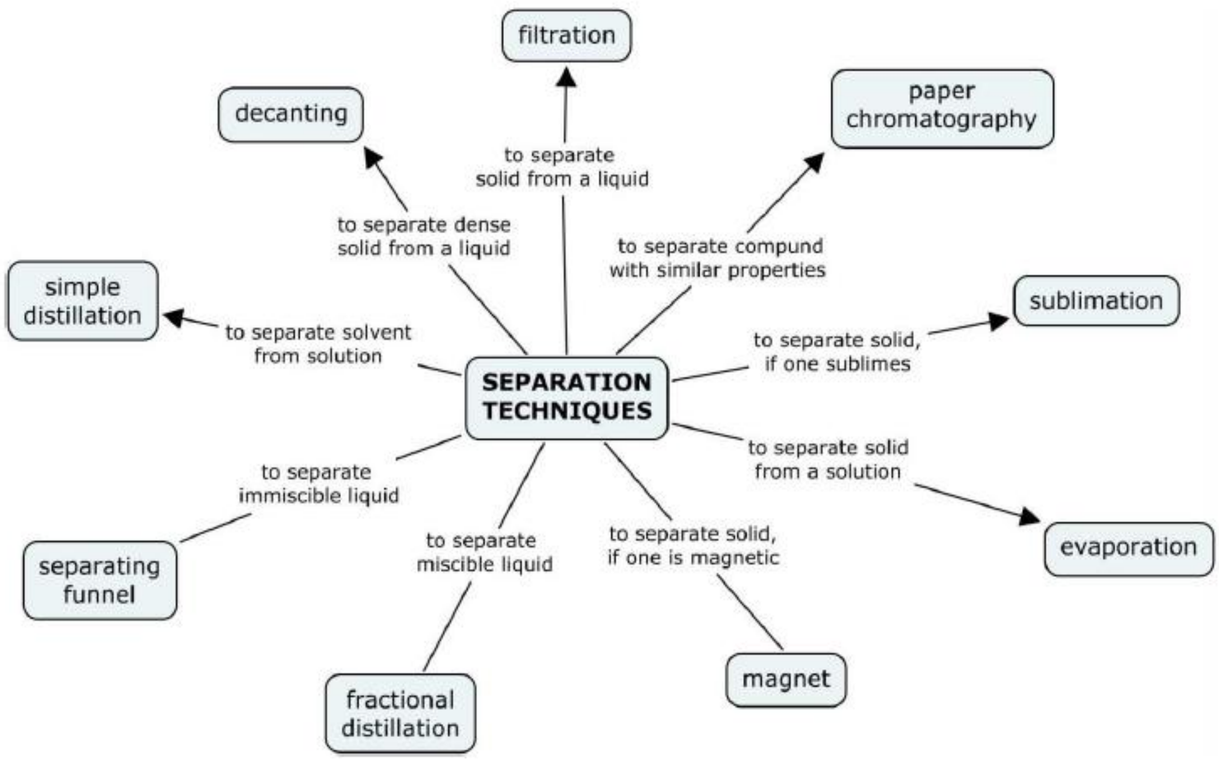

Figure 2.1b: Separation Techniques

Source:Kilic and Cakmak(2013)

2 The hierarchy concept map, as shown below, presents information in a descending order of importance. Step by step the student noted down the relevant context in the given boxes/circles. It helps to understand and co-relate the subjects. Figure 5 shows an example to the hierarchy concept map.

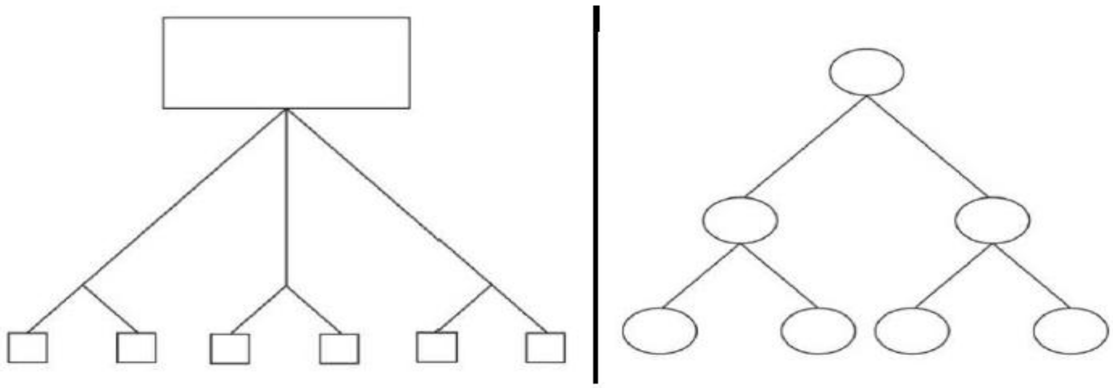

Figure 2.2a: The hierarchy Concept Map

Source: Novak (1977)

Example: Figure 2.2b is an example of the hierarchy concept map

:

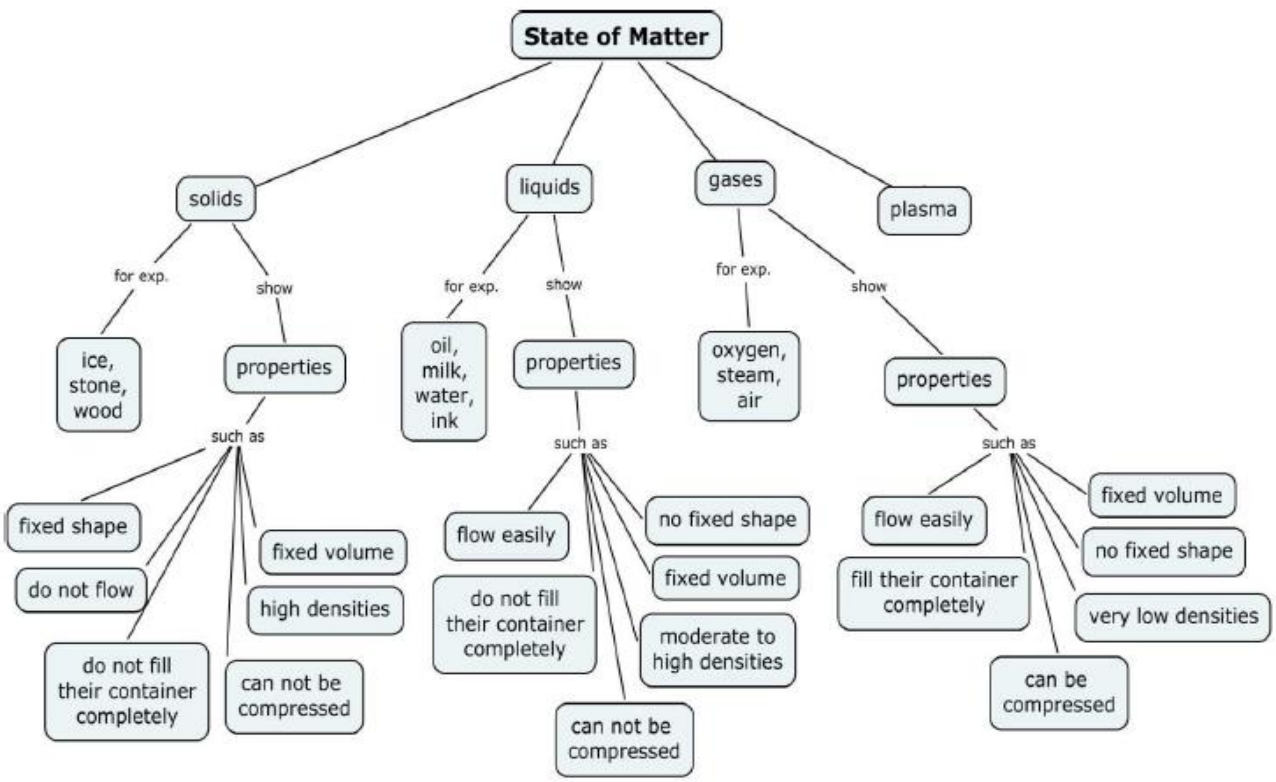

Figure 2.2b: State of Matter

Source: Kilicand Cakmak(2013)

4. The flowchart concept map organizes information in a linear format.

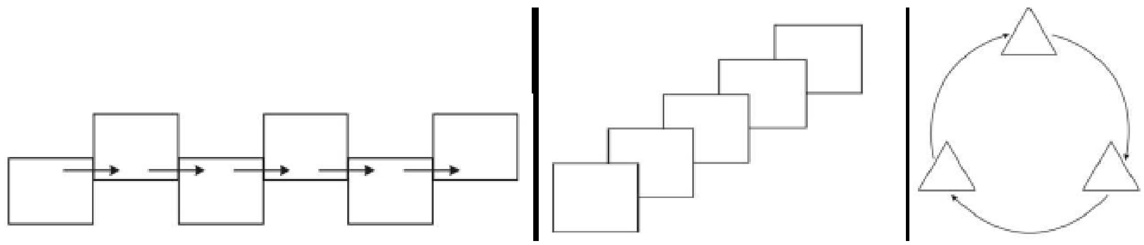

Figure 2.3a: The flowchart Concept Map

Source: Wandersee(1990)

Example: Figure 2.3b is an example of a flowchart type of concept map.

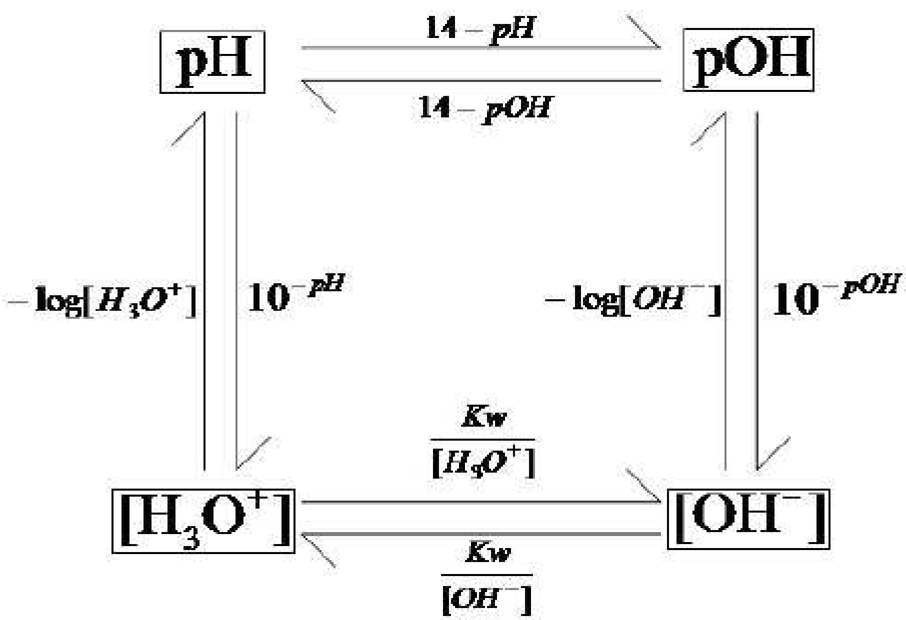

Figure 2.3b: pH and pOH

Source: Karakuyu (2010)

5. The systems concept map organizes information in a format which is similar to the flowchart with the addition of INPUT and OUTPUT. It includes all data on the map and

shows many relationships between the data. It uses critical thinking skills along with problem solving skills.

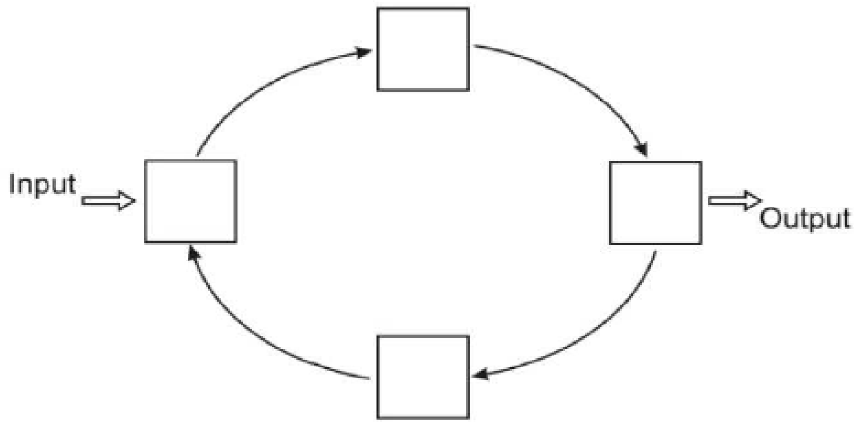

Figure 2.4a: The systems Concept Map

Source: Anderson (1993)

Example: The figure 2.4b is an example of the system concept map

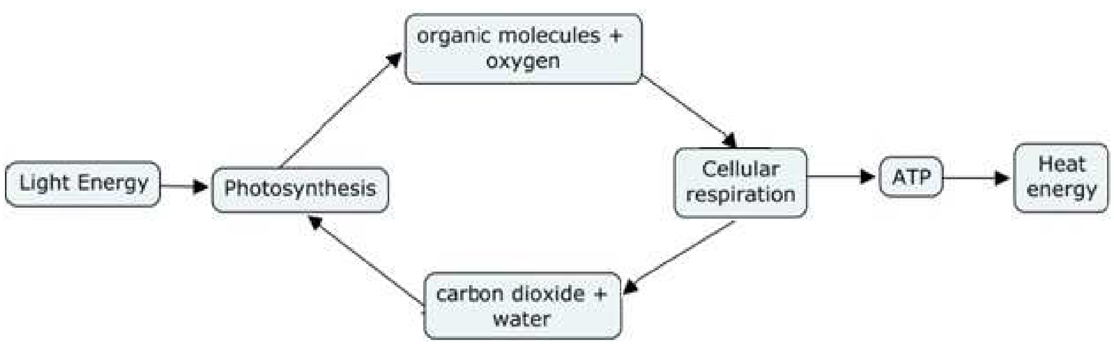

Figure 2.4b: Photosynthesis and Cellular Respiration

Source; Larbi (2011)

6. Multi dimensional (3D dimensional) concept map describes the flow or state of information or resources which are too complicated for a simple two-dimensional map.

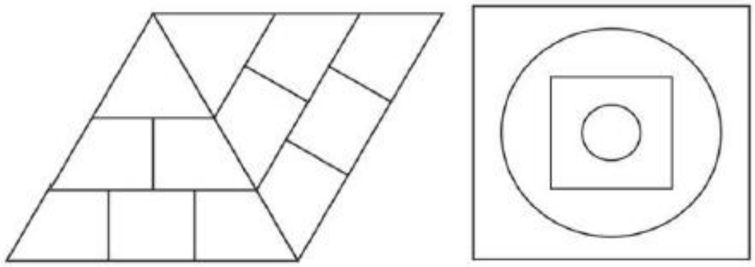

Figure 2.5a: Multi dimensional (3D dimensional) concept map

Source: Ruiz-Primo and Shavelson (1996)

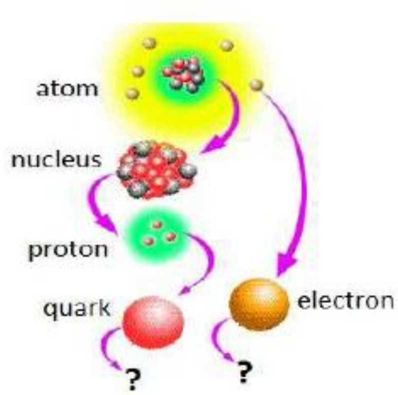

Figure 2.5b: Atom

Source: Kilic and Cakmak (2013)

However, hierarchical type of concept mapping was used in this study because according to Bamidele et al (2008), found out that there is no significant difference on students' academic achievement when exposed to hierarchical,spidal or flow chart concept mapping .

2.4.4 Objectives of Concept Mapping

Concept mapping can be done for several purposes, some of which are:

- to generate ideas through brainstorming
- to design a complex structure
- to communicate complex ideas
- to aid learning by explicitly integrating new and old knowledge

2.4.5 Construction of Concept Maps

Bello and Abimbola (1997) noted that the ability to construct good concept maps is not limited to brilliant students. Novak, Gowin and Johansen (1983), and Bello and Abimbola (1997) found out that while most high-scoring students constructed good concept maps a few of them constructed poor ones. On the other hand, while a few low scoring students constructed good concept maps, many of them constructed poor concept maps. This means that concept mapping can be used by all manner of students irrespective of their academic capabilities. However since few of the low scoring students could construct good concept maps, Bello and Abimbola (1997) suggested that they ought to be given enough time and exercises and also their cognitive efforts should be boosted to make them construct good concept maps.

To construct good concept maps, it is imperative for students to be conversant with the steps for constructing concept maps. Novak and Canas (2008) suggested that learner must

1. Begin with the domain of knowledge that is familiar
2. Identify the context of the text, the field of activity or the problem
3. Construct focus questions. These are questions that clearly specify the problem or issue the concept map helps to resolve. Every concept map responds to a focus question. A good focus question can lead to a richer concept map.
4. Identify key concepts that apply to this domain. These key concepts could be listed at first, and then ranked from most general and most inclusive at the top to the most specific and least general at the bottom of the list. This list of concepts is called parking lots.
5. Construct preliminary concept map
6. Make crosslink. These are links between concepts in different segment or domain of knowledge on the map to illustrate how these domains are related to one another. Cross links are important to show the learner that he understands the relationship between the sub-domains in the map.
7. Revise the map by repositioning the concepts
8. Construct the final map

Novak and Canas (2008) hinted that, students should be selective in identifying crosslink. They should also be precise as possible in identifying linking words. Finally students are to avoid sentences in boxes. In constructing the concept maps, students can work individually of in group or whole class with the teacher leading the discussion. Novak and Canas (2008) think that students who find it difficult to add linking words in the "lines" of their concept maps, may be having poor understanding between the concepts or the meaning of concept and linking words that specify the relationship. They assert that, students' ability to identify the prominent and useful cross links is paramount. Bloom (as cited in Novak and Canas, 2008) emphasized that this process of crosslinks involves high level of cognitive performance such as synthesis and evaluation of knowledge.

2.4.6 Usesof Concept Mapping in Teaching and Learning of Science

Concept mapping is designed to help students and others clear up ambiguities and clarify misconceptions in information (which often arise in the learning process), along with strengthening the memory and retention process after the learning is accomplished (Canas& Novak, 2008). Further explain that such improvements in education with the use of concept maps have been proven by scientific studies.

Concept mapping has been shown to help learners learn, researchers create new knowledge, administrators to better structure and manage organizations, writers to write, and evaluators assess learning(Larbi,2011).Concept maps are used to stimulate the generation of ideas, and are believed to aid creativity. For example, concept mapping is sometimes used for brainstorming. Although they are often personalized and idiosyncratic, concept maps can be used to communicate complex ideas. (Larbi, 2011).

One big advantage of using concept maps is that it provides a visual image of the concepts under study in a tangible form which can be focused very easily. They can be readily revised any time when necessary. During the formulation process it consolidates a concrete and precise understanding of the meanings and inter-relation of concepts. Thus concept mapping makes learning an active process, rather than a passive one.

Concept maps used by teachers: Concept maps are used to clarify and arrange difficult concepts in a systematic order. Concept maps used as 'Ausubelian' advance organizers also provide an initial conceptual frame for subsequent information and learning (Novak and Canas, 2008). Using concept maps to teach help teachers to be more aware of the key concepts and relationships among them. Teachers are able to convey a clear and general picture of the concepts and their relationship to students. Using concept maps reduce the likely hood of teachers missing or misinterpreting any important concepts. In presenting concepts to students, teachers should never ask students to memorize prepared concept maps. This could merely promote rote learning and so defeat the purpose of encouraging active meaningful learning on that part of the learner.

Concept maps use by students: Using concept maps reinforces students understanding and learning. This enables visualization of the concepts and summarizes their relationship. Many students have difficulty in identifying the important concepts in a text, lecture or other form of presentation. Part of the problem stems from a pattern of learning, that simply requires memorization of information, and no evaluation of the information is required. Such students fail to construct powerful concept and propositional frameworks, leading them to see learning as a blur of myriad facts, dates, names, equations, or procedural rules to be memorized. For these students, the subject matter of most disciplines, and especially science, mathematics, and history, is a cacophony of information to memorize, and they usually find this boring. Many feel they cannot master knowledge in the field. If concept maps are used in planning instruction and students are required to construct concept maps as they are learning, previously unsuccessful students can become successful in making sense out of science and any other discipline, acquiring a feeling of control over the subject matter (Bascones& Novak, 1985; Novak, 1991, 1998 cited in Novak &Canas, 2008). Concept map is a strong tool for organization and consolidation of students' knowledge base; and also for promotion of cooperative learning among students.

Concept maps used as evaluation tool: One of the powerful uses of concept maps is not only as a learning tool but also as an evaluation tool, thus encouraging students to use meaningful-mode learning patterns (Mintzes, Wandersee, & Novak., 2000; Novak &Gowin, 1984). Use of concept maps can also assist teachers in evaluating the process of teaching. Teachers use concept maps to better assess knowledge gained by their students. Traditional testing, such as with essay, multiple-choice, and fill-in-the-blank questions, is a valuable way to test students. They can assess the students' achievement by identifying misconceptions and missing concepts. Novak and Canas (2008) view concept mapping as an effective tool for evaluating students' understanding and argue that text books could include the use of concept maps to summarize students' understanding at the end of a chapter. They emphasized that "there is nothing written on stone that says that multiple choice test must be used from grade schools to the university". In other words, there is no policy on education that stated the use of only multiple choice or essay tests for evaluation, by implication concept mapping could be use to evaluate students achievement.

Concept maps used for curriculum planning: Novak and Canas (2008) have suggested the enormous use of concept maps in curriculum planning. Concept maps present in a high concise manner the key concepts and principle to be taught. As a characteristic feature of concept mapping, knowledge or ideas are presented beginning from more general and more inclusive to the more specific, hence in using concept map to plan a curriculum, curriculum developers should construct 'macro maps' showing the major ideas that are planned to be presented in a whole course or in a whole curriculum, and specific 'micro maps' to indicate the knowledge for every specific parts or segments of the instructional programme. Starr and Krajcik (1990) in Larbi(2011) developed the use of concept maps as a heuristic in the process of science curriculum and found out that the use of concept maps changed the view of teachers on curriculum. They emphasised that, the use of concept maps can assist both science teachers and curriculum specialist in developing a curriculum which meets the needs of both the teacher and the learner. Starr and Krajcik reiterated that developing science curriculum with concept maps makes science 'conceptually transparent to both the teacher and the student and this in the long run concurrently improve curriculum development in both process and product.

Concept mapping for capturing and archiving expert knowledge:According to Novak and Canas (2008), one of the uses of concept maps that are growing at a fast rate is the use of concept maps to capture the 'tacit' knowledge of experts. Experts know many things that they cannot articulate well to others. Often, experts speak of a need to 'get a feeling for what you are working on'. To Novak and Canas (2008), tacit knowledge is acquired over the years of experience and derives in part from activities that involve thinking feeling and acting. Tacit knowledge from groups or individuals is captured through three major approaches which are: interviewing experts, learning by being told and learning by observation (Collins, 2001;Nonaka& Krogh, 2009). In fact, these methods continue to be highly popular with many cognitive scientists, most of whom are unfamiliar with Ausubel's work and the kind of epistemological ideas on which concept mapping is based (Novak &Canas, 2008). Even though Novak and Canas found the above methods useful, it was necessary to invent a better way to represent what learners knew and how knowledge was changing over time. Novak and Canas (2008) used 'clinical interviews' to draw knowledge from a medical expert and from a book he had written on cardiology on how to interpret computer readings from computer outputs of a machine designed to assess problems with heart functions, following injection of a bolus of radioactive solution and diagnose coronary dysfunction (Ford, Coffey, Canas, Andrews, &

Turner, 1996). This procedure of capturing tacit knowledge could be also used to trace students' knowledge they possess about a concept of which they could not express well by using concept mapping (Larbi, 2011).

There are many reasons why concept maps are generated in the first place. They are used within an established business, such as taking simple notes at a department meeting and remembering important concepts at a board of directors meeting. A new business might use concept mapping to identify its employees' knowledge base. Computer programmers often use concept maps to design complicated computer programs, such as for creating Web sites and video games. Large organizations often use concept maps to communicate complex ideas to their employees or to the general public.

Lawyers use concept maps to illustrate arguments on both sides of complex issues. Educators frequently use concept maps to help students learn new material, retain historic material, and integrate the two together. Problem solvers use concept maps to better understand and diagnose problems. A troubled company, for example, might use concept mapping to create a shared direction to improve employee morale or increase its customer base. In summary here are some uses of concept mapping discovered by researchers: Concept mapping has been used to:

1. Document conceptual change (Hay, 2007; Markow&Lonning, 1998; Mintzes& Wallace, 1990;Novak, 2004).
2. Develop critical thinking skills (Able & Freeze, 2006; Briscoe &LaMaster, 1991; Kinchin, 2001).
3. Emphasize hierarchical relationships (Laight, 2004; Novak, 1998; Novak &Gowin, 1984).

4. Move away from rote memorization (Briscoe &LaMaster, 1991; Heinze-Fry & Novak, 1990;Kinchin, 2001; Novak, 1998; Novak &Musonda, 1991).
5. Develop reflection (Mason, 1992).
6. Transfer knowledge to novel situations (Mason, 1992).
7. As a Communication tool between teacher and student (Roth, 1994).
8. As a Compensation for different learning styles (Huai, 1997).
9. Improve student achievement (Hay, 2007; Horton *et al.*, 1993).
10. Expose misconceptions (Heinze-Fry & Novak, 1990; Kinchin& Hay, 2000; Novak &Gowin, 1984).
11. Evaluation/testing (Kinchin*et al.*, 2005).
12. Facilitate creative production of knowledge (Novak, 2004).

According to Kilic and Cakmak (2013), there are several reasons why concept mapping is used as an instructional strategy. These are as follows:

1. primary benefit of concept mapping is that concept maps can be obtained from the visual Presentation of ideas based on the deduction for impairment.
2. It addresses different forms of learning and individual differences between students. It means samesubject or same concepts can be drawn differently for the individuals.
3. It can be used easily for the creation and integration of the scope of the assessment.
4. Concept map is student-centered, active teaching method. It can encourage student-teacher interactionwhen they create a map together by discussing.
5. It is very useful for showing alternative relationships within a system
6. After learning this technique, students get used to establish links between concepts rather than recallingconcepts separately.

7. It can be used effectively for revision after a topic. And students are able to rank topics which they learn.

8. It develops the social aspect (confidence level) of students for being able to speak during construction.

9.Provides clarity of the concept.

10.It is a good way to work and prepare for the exams.

11. It is suitable for many different topics, instructional stage and grade level

12. It is easy to use for teaching and learning.

2.5 Lecture Method of Teaching

According to Brown (1987), the term lecture was derived from the Medieval Latin"Lecture" to read aloud. So, Lecture consisted of an oral reading of a text followed by a commentary. This is the oldest and the most common method in use at the tertiary level of our institutions. It is the process whereby the teacher verbally delivers a pre-planned body of knowledge to his students. The teacher talks while the students listen and jot down essential points. This method is teacher-centered. The teacher is the most active while students are passive. It is therefore used to teach a large group of students who are usually passive listeners with little or no opportunity to ask questions. Many researchers have compared the traditional method to other methods of teaching in students' achievement. They found out that students normally taught with other methods do perform better than those taught with the traditionalmethod. For instance, Apafo (as cited by Wood, 2007) conducted a study in Cape Coast using 45 males in Senior Secondary School on the topic balancing of chemical equation. The experimental groups were exposed to games' simulation approach and the control group exposed to traditional method. He reported that the experimental group achieved significantly higher than the control group.

Larbi (2005) also conducted a study in the eastern region of Ghana comparing the indigenous method approach to the traditional method of teaching. He found out that students taught with indigenous method of teaching science achieved significantly higher than those taught with the traditional method. Likewise, Wood (2007) reported that students who were exposed to the constructivists approach achieved significantly higher than their counterparts exposed to traditional method. Research shows that those exposed to concept mapping achieved significantly than those exposed to traditional method (Akpinar&Ergin, 2008; Asan, 2007; Bos& Anders, 1990; Bunting et al 2005; Jegede et al 1990 and Seaman,1990).

Finally the advantages and disadvantages of lecture model can be summarized asfollows (Sampath et al., 1987).in vin-Mbah (2012)

Advantages

- The proper perspective and orientation of a subject can be presented and thegeneral outline of scope of the subject can be brought out.
- Many facts can be presented in a short time in an impressive way.
- The lecture can stimulate very good interest in the subject.
- Greater attention could be secured and maintained, as interest leads toattention.
- Spoken word has greater weight than mute appeal by books.
- The language may be made suitable to all the members of the audience.
- Lecture can prsesent a number of facts belonging to different subjects and it can facilitate inter-disciplinary approach to topics.

Disadvantages:

- It is waste of time to repeat the matter already present in books.
- The teacher to make the lecture impressive may care more for manner andstyle but very little for matter or content.
- If the lecture is very fast, the pupil cannot easily take notes and will not haveany written record of the salient points made out.
- A lecture delivered in a style not easily understood by pupils will serve nopurpose.
- In the process of lecturing, the learners are more passive than be active inclass.
- The problem solving attitudes of pupils may disappear in the lecture method.
- There is no cooperation and interaction between the teacher and pupils in thelecture process.

In spite of the numerous disadvantages of lecture method and researches conducted to prove the inefficiency of the method, it remains a popular method of teaching in Nigeria. As Kauchak and Eggen (1988) concluded, lectures remain popular for several reasons as follows:

1. They are efficient, planning time is devoted to organizing the context. Less attention has to be devoted to teaching strategy.
2. They are flexible and can be adapted to a wide range of subjects.
3. Most people can learn to lecture well enough to survive in a classroom.
4. Lectures are easier to learn than most other instructional strategies.
5. They are easier for teacher due to simply “telling” students about the subject

2.6 Concept of Reflective Thinking

Critical thinking and reflective thinking are often used synonymously. Critical thinking involves a whole range of thinking skills leading toward desirable outcomes and reflective thinking focuses on the process of making judgments about what has happened. However, reflective thinking is most important in promoting learning during complex problem-solving situations because it provides students with an opportunity to step back and think about how they actually solve problems and how a particular set of problem solving strategies is appropriated for achieving their goal. Reflective thinking involves personal consideration of one's own learning. It considers personal achievement and failures and asks what worked, what didn't, and what needs improvement (Given, 2002). It asks learners to think about her own thinking

2.6.1 Why it is Necessary to Determine Students' Reflective Thinking

Modern society is becoming complex, information is becoming available and changing more rapidly prompting users to constantly rethink, switch directions, and change problem-solving strategies. Thus, it is increasingly important to prompt reflective thinking during learning to help learners develop strategies to apply new knowledge to the complex situations in their day-to-day activities. Reflective thinking helps learners develop higher-order thinking skills by promoting learners to:

a. relate new knowledge to prior understanding

b. think in both abstract and conceptual terms

c. apply specific strategies in novel tasks and

d. understanding their own thinking and learning strategies

2.6.2 How to Prompt Reflection in Students

It is important to prompt reflective thinking in middle school children to support them in their transition between childhood and adulthood. During the time period adolescents experience major changes in intellectual, emotional, social and physical development. They begin to shape their own thought processes and are at an ideal time to begin developing thinking, learning, and metacognitive strategies. Therefore, reflective thinking provides middle level students with the skills to mentally process learning experiences, identify what they learned, modify their understanding based on new information and experience, and transfer their learning to other situation in the society.

Scaffolding strategies should be incorporated into the learning environment to help students develop their ability to reflect on their own learning. For example;

- Teachers should model metacognitive and self-expansion strategies on specific problems to help students build an integrated understanding of the process of reflection.
- Study guides or advance organizer such as concept map should be integrated into classroom materials to prompt students to reflect on their learning
- Questioning strategies should be used to prompt reflective thinking, specifically getting students or respond, why, how and what specific decisions are made.
- Social learning environments should exist that prompt collaborative work with peers, teachers and experts.
- Learning experiences should be designed to include advice from teachers and co-learners.

- Classroom experiences should involve enjoyable, concrete and physical learning activities whenever possible to ensure proper attention to the unique cognitive, affective and psychomotor domain development of middle school students.
- Classroom activities should be relevant to real-world situations and provide integrated experiences.

2.6.3 Characteristics of Environments and Activities that Prompt and Support Reflective Thinking

The *learning environment* prompts students to construct meanings actively and reflectively. Providing learner-controlled instruction encourages students to make their own decisions regarding their learning progress (Duffy & Cunningham, 1996; Williams, 1996). There are certain situations that prompt and support students to develop their reflective thinking skills during teaching and learning situation. These are:

- Provide enough wait-time for students to reflect when responding to inquiries
- Provide emotionally supportive environments in the classroom, encouraging re-evaluation of conclusions.
- Prompt reviews of the learning situation, what is known, what not yet known, and what has been learned.
- Provide authentic tasks involving ill-structured data to encourage reflective thinking during learning activities.
- Prompt students' reflection by asking questions that seek reasons and evidence.
- Provide some explanation to guide students' thought processes during explorations.
- Provide a less-structured learning environment that prompts students to explore what they think is important.

- Provide social learning environment such as those inherent in peer-group works and small group activities to allow students to see other points of view.
- Provide reflective journal to write down students' positions, give reasons to support what they think, show awareness of opposing positions and the weaknesses of their own positions.

2.6.4 The Eight Steps of Reflective Thinking

Eight steps of reflective thinking are used to guarantee complete coverage of a defined problem area in problem solving. Primrose (2003) stated the eight steps of reflective thinking which are extensions of the five-step methods proposed by John Dewey. The eight steps are as follows:

A. Problem Definition

1. Formulate the problem into a definitive statement.
2. Define any terms that might be misunderstood or misinterpreted into a working glossary. The definitions proposed are decided upon by the group, only for the duration of the exercise, and may not reflect all individual interpretations. This glossary will be a useful supplement to the final report document.

B. Problem Analysis

i. Diagnose the problem in terms of cause and effects.

ii. Describe existing evils, effects or symptoms of the problem together with such interpretations and evidence as have significantly affected you thinking.

iii. Follow up with a statement of the cause or causes of the symptoms as you understand them.

a) State the probable cause of the symptom.

b) Give the factual material upon which your conclusions are based.

c) If the problem lends itself to more efficient coverage by subgroups, the problem should be divided among logical subgroups.

d) The problem definition should be modified continually as the analysis proceeds.

e) The results of the problem analysis should be documented in written form, and should include background information, and justification for the need of a solution to the problem as presented.

C. Criteria Selection

a) Create a concise statement of the standard or standards which in your opinion should be considered in judging the possible solutions.

b) Give special attention to the formulation of definite criteria for the judgment of a final solution.

c) These standards should represent the values which you think are important and which should be considered in any solution.

d) Arrange criteria in order of priority.

e) Assign an arbitrary value or weight to each selected criterion from 1 to 10 with 10 being high, representing the arbitrary value of that criterion to the group.

D. Information Analysis

i. Identify the information still needed for a solution of the problem.

ii. Gather, or make plans for obtaining the information still required.

a) Arrange an itinerary of expert testimony that can be scheduled to give information to the group about the problem as defined. Keep a careful log of the information given.

b) Arrange for required interviews by individuals, subgroups, or group. Keep careful log of the information given.

c) Arrange for the use of the needed libraries or repositories.

d) The testimony of all experts and other information gathered should be carefully documented.

E. Propose Solutions

i. Using brainstorming techniques, propose and record as many different solutions as can be thought of with no value-judgment being made.

ii. Set forth those of the proposed solutions to the problem which you think merit consideration.

iii. For each of the final proposed solutions a careful evaluation of how well each of the criteria presented in step 3 are met (The weighted factor analysis). For each proposed solution an arbitrary factor of 1 to 10, with 10 being best fit, should be made for each established criteria. This factor should be multiplied by the importance factor assigned in step 3, and the collection of all of these numbers, one for each criterion, should be added together. The proposed solution with the highest number should be the leading contender.

iv. Do the problem definition, the problem analysis, the criteria selected, and the information analysis still seem adequate (steps 1, 2, 3, and 4)? If the leading contender does not seem to be the one that should be picked, then you need to reexamine the criteria list for completeness, reexamine your feeling of how important each criteria is to you, reexamine your evaluation of each proposed solution as to how well the group feels that it meets the criteria, recheck the mathematics,--or believe what this exercise is trying to tell you. There may be hidden agendas present that are throwing you off and which must be incorporated.

v. Use the biggest part of the time allotted to the study in careful reiteration of steps 1 to 5 to this point again and again to avoid premature selection. The selection process, steps 6 to 8, should result in implementation and not rationalization for a premature and inappropriate selection.

F. Select Solution(s)

i. Using the technique suggested in step 5-c or whatever means the group chooses select tentative solution.

ii. Declare the basis for your solution, such as:

a) The solution deals adequately and practically with the problem.

b) The solution measures up best in terms of the standards and criteria.

c) List the details of the proposed plan.

d) Discuss and acknowledge the disadvantages, the advantages, and the other aspects of the proposed plan.

G. Implement Solution(s)

i. List possible methods of putting the proposed solution into operation. Document the facts and the ideas used.

ii. Develop a workable, practical method of scheduling the solution into operation.

iii. Prepare a time-sequence analysis for implementation of the plan.

H. Feedback Analysis

i. Establish suitable quantifiable measures of performance which can be used to monitor and evaluate in some way the operation of the selected solution. Compare the expected level of operation with the established criteria in step 3.

ii. Establish necessary criteria for determination if successful operation has been attained or if additional correction is necessary.

iii. Establish method for the reevaluation of the solution as to its elimination of the problem, its provision for the obsolescence of the proposed solution, or for the consideration of a significant change of the problem situation. Provide for our "help" to self-destruct in not needed

2.5.5 Effects of Concept Mapping on Reflective Thinking

Brookfield (1995) indicates that, it is helpful to first have students create a record of what they were thinking at a particular point in time, and then to go back at a later point in time and analyze that thinking. Concept maps can serve as a record of a student's thinking that allows for later reflection and analysis.For students to effectively construct concept map, there is call for reflection,ability to identify the relationship between concepts using ones previous knowledge. According to Samuel and Peter (2013) Students must reflect on their previous understanding of the issue and their newly acquired knowledge in order to respond to an issue. Thus reflection helps students to develop higher-order thinking skills and prompt them to relate new knowledge to their prior understanding, think in both abstract and concrete terms, apply specific to a given tasks and understand their own thinking and learning (Ferari&Hemelo,1999 citedinSamuel&Peter2013).

2.6.6 Effects of Reflective Thinking on Academic Performance

In educational psychology research interest has emerged in the study of reflective thinking as possible antecedent of future academic achievement (Phan, 2007&2008).Leung and Kember (2003) based on Mezirow's theoretical framework advocated that reflective thinking may be categorized into four distinct phases; in their order of importance; habitual action, understanding, reflection and critical thinking.

Research has shown that in general the four phases of reflective thinking make a contribution to the prediction of academic achievement. For example, habitual action and understanding are related negatively with academic achievement (Phan, 2007&2008) .Whereas reflection and critical thinking positively predict academic achievement (Phan, 2008). In this study the researcher sought out to investigate whether students with high reflective thinking perform better academically than those with low reflective thinking when exposed to concept mapping strategy.

2.7 Academic Performance in Chemistry in Secondary School

In spite of the central and important position of chemistry among others science and related disciplines, studies revealed that, academic achievement of students in chemistry at Senior Secondary School Certificate Examination (SSSCE) has consistently been very poor and unimpressive (Njoku, 2005). The West African Examination Council (WAEC) Chief Examiners Report 2009, 2010, 2011 and 2012, reported students' general poor performance in chemistry(Dahiru,2013).

Many factors have been suggested as contributing to the poor performance of students in chemistry in particular and science in general. Some of these factors include: inadequate laboratory equipment in chemistry (Eniayeju, 2010); poor teaching methods (Ayogu, 2001); mathematical nature of chemistry among others. In summary, the problems militating against the advancement of science education have been well documented (Okoye, 2002) these are;

- Lack of adequate textbooks
- Lack of fund to purchase equipment
- Overcrowded classroom, laboratory, timetable
- Lack of cooperation by school administrators
- The pressure of external certificate examination
- Lack of proper monitoring and feedback mechanism
- Poor preparation of teachers who teach new programmes
- Lack of motivation among teachers
- Rapid rate at which teachers are transferred from one school to another or out of the profession.
- Overwhelming number of activities demanded by the new curricula and
- Shortage of qualified teachers.
- Inappropriate teaching method

2.8 Gender and Academic Performance in Secondary School

The term gender is socio-cultural and is built based on the biological expectations of the individual on the basis of being a male or female. Gender has sound psychological background and is used to refer to specific cultural patterns of behavior that are attributed to human sexes.Gender, then, refers to a set of assumptions about the nature and character of biological differences between males and females, assumptions that manifest in a number of ideas and practices that have a determinant influence on identity, social opportunities and life experiences of human actors(Taylor,1999 cited inSamuel,2012). In Nigeria and Africa in general, gender biasness is still prevalent (Arigbabu&Mji, 2004). Erinosho (2005) asserted that, these biases and misconception about women and science are great challenges in the field of science education as people continue to describe science as a male enterprise. This according to Onyeizugbo (2003) is due to the sex roles which are rigid in Africa and Nigeria in particular, where gender differences are emphasized. No wonder that the school which is seen as a microcosm of society consciously or unconsciously perpetuates stereotyping behaviour, with teachers exhibiting gender biasness in the classroom (Arigbabu&Mji, 2004).

In the educational system, gender is important as it tends to influence the pattern of school enrolment and academic performance of students. This is partly because gender roles affect familiarity with academic content, career aspirations, attitude toward subjects, teacher expectations and preferred approaches which also affect academic performance (Owodunni,2012).In most societies, gender role has relegated females to the sidelines, preventing them from participating in and benefiting from educational and development efforts.

Many scholars have researched into gender differences in academic achievement especially in sciences and mathematics. Many have found that the male students performed better than their female counterparts (Oyedeji,1996; Ayedun.2000; Etukudo, 2002 & Kolawole2002). But, a few scholars have also found no significant difference in academic performance in science and mathematics between male and female students (Ogunkola&Owolabi 2000 &Kurumeh, 2004). The controversy as to which of the sexes would have better academic performance therefore, continues.

This study was designed to determine if gender difference in academic performance and reflective thinking would occur when students are thought mole concept using concept mapping strategy.

2.9 Overview of Similar Studies

Many scholars and researchers have used Concept Mapping as teaching strategy in various subject areas. Here are some of the studies carried out:

Bello and Abimbola (1997) conducted a study on gender influence on Biology students' concept mapping ability and achievement in evolution using eighty seven SS2 students, found out that the ability to construct good concept maps is not limited to any student gender. They indicated that ability to construct properly integrated and complex concept maps was observed among both male and female student. However, the percentage of male students who constructed good concept maps was slightly higher than their female counterparts. It is important to explicitly indicate that concept map construction processes are free from sex related skills hence no particular gender has an advantage over the other. They also found no significant difference in achievement in evolution between male and female students who were taught using the concept mapping method. They argued that this finding was so because the items in the achievement test were free from sex related issues and that the concept mapping technique used was a novel experience to all the students who took part in the study. They therefore concluded that concept mapping as an instructional strategy could be used in mixed gender classroom situation.

Otor(2013) investigated the effects of concept mapping strategy on secondary school students 'achievement on difficult chemistry concepts using 1,357 SS2 students from two Local government schools, Benue. He also examined the differential effect on the achievement of male and female chemistry students. Students taught using concept mapping strategy achieved higher and significantly better than those taught using conventional method. There was also a better performance in favor of female students compared to their male counterparts using this method. The study recommended among other things, adequate training of chemistry teachers on the use of concept mapping strategy in teaching chemistry at the secondary school level.

Bamidele,Adetunji.Awodele and Irinoye (2013) studied on Attitudes of Nigerian Secondary School Chemistry Students towards Concept Mapping Strategy in learning the Mole Concept. They used one hundred and thirty two SS2 students in Osun state. Results showed that there was no significant difference in the performances of thestudents exposed to Hierarchical, Flowchart or Spider Concept Mapping strategies when used as advance organizers.

This implies that using any of the concept mapping strategies as advance organizers produced a similar effect on the students' performance in their problem solving abilities. Result also indicated that there was no significant difference in the students' attitude to the concept mapping strategies. That is, those students that were taught with concept mapping strategies have similar attitudes to the strategy. It is therefore concluded that the various types of concept maps used in this study were effective and students had similar attitude to the maps.

Larbi(2011) also carried out a research work to compare the concept mapping approach which is based on constructivist theory to the traditional method of teaching biology in senior high schools. Two intact classes were randomly selected from five co-educational Senior High Schools (SHS3) offering elective biology in the New Juaben Municipality.The design used was the pretest post nonequivalent quasi design.sThe sample size was 105 students. The results indicated that those instructed with concept mapping did better than those instructed with traditional method. The result also revealed that both males and females constructed concept maps alike. Also those exposed to concept mapping showed positive perception towards concept mapping. It has been recommended that much attention should be given to students concerning analysis and other high order cognitive level questions.

Adlaon (2013) in his work on effectiveness of using concept maps in improving the science achievement of thirty four (34) 10th -grade students and compare it with a traditional approach in biology. The first finding of the study was that concept map – exposed students did not perform much better than the same level students in the traditional group. The difference in the learning gains between the experimental and the control group in their unit test, though statistically significant, did not seem to be solely due to concept mapping. The second finding indicated that total scores in concept maps did not strongly predict student achievement in Science. Moreover, results showed that the levels of concept mapping ability were not associated with the concept- mapping students' learning gains. Nevertheless, the study suggests that, when carefully integrated into the normal classroom procedure and when other contributing factors such as student motivation and preparedness, reading ability levels, time and classroom environment are considered, concept mapping has a potential to be an effective instructional strategy.

Cheema and Mirza (2013) investigated effects of concept- mapping a constructivism based learning strategy, on academic performance of 7th grade students in the subject of general science. The study involved 167 students from two single sex schools. Results showed that the male and female students taught through concept mapping performed better than the students taught through traditional teaching method. However male students taught through concept mapping performed significantly better than the female students. It is therefore recommended that concept mapping should be used in elementary classes for teaching general science.

Jack (2014) alsodetermines the effects of concept mapping learning strategies on Secondary students‟ academic achievement in chemistry. She used 100 SS1 students in Taraba State, Nigeria. The present findings indicate that the use of concept mapping as a teaching–learning strategy has a positive effect on learning and also showed a significant difference in estimated retention between students who used concept mapping and those who used traditional method. There were also significant effects of anxiety on the students‟ post and delayed-post academic achievement scores in chemistry. It was clear that the concept maps have great influence on learning, thus, students should be taught how to prepare it and it was recommended that teachers should also teach students using concept maps in chemistry since what is learned through it can be retained for a long time.

Karakuyu (2010) investigated the effects of students’ concept mapping on their physics achievement and attitudes toward physics lesson. Participants were 58 ninth-grade students from the two classes’ enrolled to general physics course in a high school in Turkey. One of the classes was randomly chosen as experimental group (28), constructed electricity concept map and the other was control (30) group, did not receive any presentation on concept mapping. Results showed that while there were no significant differences in the attitude and achievement between the experimental and control groups. However, the experimental group students were observed to have a tendency of more positive attitude than the control group students. Results also showed that drawing concept map instruction was more effective than traditional instruction in improving physics achievement of the participating students.

In the study of Willerman and Harg (2006)which aimed to determine if concept map used asan advance organizer can improve the scienceachievement of eighth-grade students, Eighty two(82) students in four science classes participated in this study, two classes as experimental.

Theresult showed that concept map can provide theclassroom teacher with meaningful and practicalstructured approach for using advance organizersin their classes.

Mahasneh (2013)examined the relationship between reflective thinking and learning styles among Jordanian university students. Participants of the study consisted of (476) students (male and females) selected randomly from different faculties of Hashemite University. Regression and correlation analysis were used for data. Results indicated that there is significant positive correlation between deep learning styles and habitual action and critical reflection. Results also indicates that no significant correlation between Surface and strategic learning styles and other dimensions of reflective thinking.

2.9 Implications of Literature Reviewed on Present Study

The review of literature made the researcher to discover that very little studies were conducted on reflective thinking in and outside the country.And from literature reviewed most of the studies on concept mapping did not cater for reflective thinking more especially in chemistry which this study fill the gap. Literatures have revealed that series of researches were carried out on concept-mapping strategy. For exampleLarbi (2011), Jack (2014), Cheema and Mirza (2013), Willerman and Harg (2006),Adloen(2013),Otor (2013) and many more investigated on the effects of concept-mapping strategy on students' academic performance. They all found out that students taught using concept-mapping strategy performed better than those taught using lecture methodAlso Karakuyu(2010) and Bamidele et al(2013) studied on students attitude when taught using concept mapping strategy, While some researchers worked on students perception, anxiety and interest .From all the studies however, the researchers were either trying to find out students' academic performance, anxiety, interest, attitude and perception when taught using concept mapping strategy.In spite of the numerous researches conducted on concept mapping strategy in various subject areas, none addressed the level of students' reflective thinking.Theaspect of finding the level of students' reflective thinking when taught using concept-mapping strategy was not addressed in the literatures cited. Therefore, this study sought to fill the gap. This research howeverinvestigated the effects of concept mapping strategy on reflective thinking and academic performance in mole concept among secondary school student. The literature reviewed has also guided the researcher in developing data collection instruments. The review was found to be significant in assessing the number of studies done previously which is related to this field.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This study investigated the effects of concept mapping on reflective thinking and academic performance in mole concept among secondary school chemistry students in Giwa education zone, Kaduna State, Nigeria. The chapter is presented under the following sub-headings;

- Research Design
- Population of the Study
- Sample and Sampling Technique
- Instrumentation
- Validation of the Instruments
- Pilot Testing
- Reliability of the Instruments
- Administration of Treatment
- Procedure for data Collection
- Procedure for data Analysis

3.2 Research Design

This study adopted pre-test, post-test quasi-experimental-control group design as proposed by (Kerlinger, 1973). The study involved two groups; experimental and contol groups consisting of both male and female students.Pretest was administered to the two groups, before the treatment, to determine the groups' equivalence based on the ability of the students. The experimental group studentswere taught mole concept using concept mapping strategy while the control group students were taught the same concept using the lecture method. At the end of the treatment period (six weeks), a posttest was administered to both groups of students in order to determine the effectiveness of the treatment on the students. The scores collected were analyzed using t-test and Pearson Product Moment Correlation. The design of the study is represented as follows;

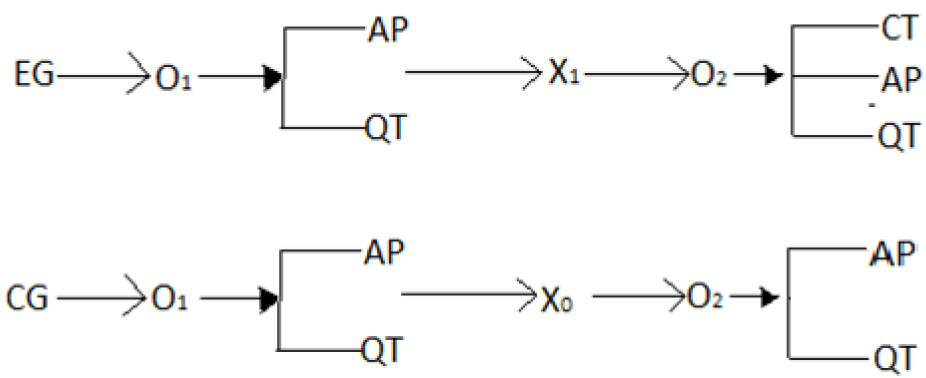

Fig 3.1: Research Design
Adopted from Kerlinger (1973)

Keys:

EG - Experimental Group

CG - Control Group

X_1 - Treatment (Concept Mapping Strategy)

X_0 - No Treatment (Lecture Method)

O_1 - Pretest

O_2 - Posttest

CT - Concept Map Construction

QT - Reflective Thinking Questionnaire

AP - Academic Performance

In this research design, selection bias is minimized or eliminated because the experimental and control group are in two different schools. Also, the effect of instrumentation could easily be controlled and effect of regression could be ruled out since both the experimental and control group are made up of equivalent subjects. Even though this design suits this study, it has some weaknesses. The major weakness lies in some extraneous factors such as age, ability, maturation and previous learning experiences whichwere not controlled in this study. Another weakness of this design which is a threat to internal validity is the interaction between the control and the experimental groups notably when both groups are on same school premises. However, this weakness was reduced in this study sincethe location of both groups was far apart.

3.3 Population

The population for this study comprised all the public senior secondary II chemistry students (SS2) in Giwa Education Zone, Kaduna State, Nigeria. In Giwa education zone, there were 14 public schools comprising of 12 co-educational and 2 single sex schools with a total population of 643 students. Records of enrolment showed that there were 643 students which comprise of 271 girls and 372 boys with average age of 16.

The choice of public school was made because those schools comprise of students with average academic performance, age and financial status. By extension, results obtained at the end of the study can be generalized. The Table 3.1 shows the summary of the students' population in the 14 public schools.

Table 3.1: Population of the Study

S/N	Name of Schools	Nature	No. of SSII Chemistry Students		
			Male	**Female**	**Total**
1	Govt. Sec. Sch. Kwangila	Co-educational	38	15	53
2	Govt. Sec. Sch. Jama'a	Co-educational	19	18	37
3	Govt. Girls Sec. Sch. Samaru	Girls only	-	43	43
4	Govt. Sec. Sch. Basawa	Co-educational	27	12	39
5	Govt. Sec. Sch. Bomo	Co-educational	35	20	55
6	Yusuf Aboki Sec. Sch. Shika	Co-educational	38	14	52
7	Dr. ShehuLawal G.G.S.S. Giwa	Girls only	-	48	48
8	Govt. Sec. Sch. Giwa	Co-educational	38	17	56
9	Govt. Sec. Sch. Yakawada	Co-educational	21	15	36
10	Govt. Sec. Sch. Fatika	Co-educational	26	14	40
11	Govt. Sec. Sch. Gangara	Co-educational	14	7	21
12	Govt. Sec. Sch. Sakadadi	Co-educational	19	06	25
13	Govt. Sec. Sch. Hunkuyi	Co-educational	31	23	54
14	Govt. Sec. Sch. Kudan	Co-educational	42	19	61
		Total	**391**	**276**	**643**

Source: Giwa Zonal Education Office (2013)

3.4 Sample and Sampling Techniques

Simple random sampling technique using 'balloting method was used to select 2 senior secondary schools out of the 14 senior secondary schools in the population. This was achieved by writing the names of each secondary school on pieces of paper, folded and poured them inside a container. A child was asked to hand-pick 2 papers. The two schools selected formed the subjects of the study. This method ensured that each of the members of the population had equal and independent chance of being selected. Pretest was administered to determine the equivalence in their academic ability. The result obtained from the two selected schools showed no significant difference in their academic ability. The comparison was done so as to eliminate bias in the selection of sample and groups (experimental and control). The school selected first was assigned as the experimental group and the school selected second was assigned the control group. The SS2 students were also selected purposively for the study, because the concept of Stoichiometry is in SS2 curriculum. Table 3.2 shows the sample of the study.

Table 3.2: Sample of the Study

S/N	Schools	Male	Female	Total	Group
1	GSS Jama'a	19	18	37	Experimental
2	G.S.S Basawa	27	12	39	Control
	Total	46	30	76	

The choice of seventy six students selected was viable for the study and is in line with the central limit theorem. Tuckman (1975) recommended that a sample size of minimum of 30 subjects is viable for experimental study of this nature.

3.4.1 Selected Sub-topics Taught

The selectedsub-topicstaught to both experimental and control groupson mole concepts were: Amount, Molar mass, Atomic mass, Mass concentration, Molarity, Mass, Chemical quantities and units, Avogadro's number and Percentage composition of element in a compound.The choice of selecting these topics were made based on the work of Bamidele et al (2013) .They found out that stoichiometry is one of the difficult topic in chemistry taught at senior secondary schools and thereby requires the knowledge of mole concept in solving it.

3.5 Instrumentation

In this research, three instruments were used for data collection. These were Mole Concept Performance Test (MCPT), Mole Concept Construction Test (MCCT) and Reflective Thinking Questionnaire (RTQ).The MCPT designed by the researcher was used to measure students' academic performance,MCCT was used to determine students' ability to construct a concept map while the QRT measured the level of students' reflective thinking. The researcher adapted the Reflective Thinking instrumetnt designed by Kember, Leung, Jones, Loke, McKay, Sinclair, Tse, Webb, Wong andYeung(2000) and Mole Concept Construction Test instrument by Romance and Vintale (1997).

3.5.1 Mole Concept Performance Test (MCPT)

The MCPT consists of 30 multiple choice questions with five options constructed to serve as pretest to ascertain equivalence of ability of subjects and as posttest to determine the effects of the treatment on ability to solve numerical problems in chemistry based on the Mole Concept. The items consist of 15 calculations and 15 theories on mole concept. The instrument SPT was developed from past question papers of external examination bodies (WAEC and NECO) and practical chemistry by Ojokuku. Monotonous scoring of 1 mark is awarded for each question. Examples of MCPT are:

1. Which of the following units is used to represent the chemical quantity of a substance as a number of particles? (a) Kilogram (b) Ampere (c) gross (d)Mole (e) Joules
2. The number of moles represented by 23.0gram of Nitrogen (iv) Oxide NO_2 is (a) 0.5 (b) 1.5 (c) 1.0 (d) 2.0 (e) 3.0

Table 3.3 Shows the Table of specification on Mole Concept Performance Test questions. A copy of the Mole Concept Performance Test (MCPT) is found in (Appendix A).

Table 3.3 Item Specification for MCPT Based on Sub- topics Selected

S/NO	Sub-topics	No of Items	Total no of items
1	Percentage composition	20, 21,22	3
2	Molarity	10, 28	2
3	Molar mass	5,8,9,12,17	7
4	Mass concentration	16, 6	2
5	Amount	7,14,18,19,	4
6	Units	1,2,3,4,13	5
7	Mass number and atomic number	15,25,26,27,29.30	6
8	Mass	11,23,24	3
	Total		30

Table 3.3 shows the classifications of Mole Concept Performance Test items based on the eight sub-topics. A total of 30 test items made up the Mole Concept Performance Test.

Table 3.4: Table of Specification Based on Blooms' Taxonomy in the Cognitive Domain

S/no	Contents	Weight (100%)	Knowl (30.0)	Comp. (20.0)	Appl. (16.7)	Analy. (16.7)	Syn. (10.0)	Eval. (6.7)	Total
1	Amount	16.7	1	0	1	1	0	2	5
2	Atomic no	6.7	2	0	0	0	0	0	2
3	Atomic mass	6.7	0	2	0	0	0	0	2
4	Molar mass	13.0	1	0	1	2	0	0	4
5	Molarity	6.7	0	0	2	0	0	0	2
6	Mass conc.	6.7	1	1	0	0	0	0	2
7	Avogadro's no	6.7	1	0	0	1	0	0	2
8	Unit	16.7	2	3	0	0	0	0	5
9	Mass	10.0	1	0	1	1	0	0	3
10	Percentage	10.0	0	0	0	0	3	0	3
	Total		9	6	5	5	3	2	30

Source: Adapted from Bamidele et al (2013)

3.5.2 Reflective Thinking Questionnaire (RTQ)

The Reflective Thinking Questionnaire (RTQ) developed by Kember, Leung, Jones, Loke, McKay, Sinclair, Tse, Webb, Wong andYeung(2000) contains 16 items descriptive of the four types of reflective thinking advocated (Mezirow,1991).The 16 items in the questionnaire are made to measure the four scales of reflective thinking (habitual action, understanding, reflection and critical reflection) on a five-point scale ((1) definitely agree,(2)agree with reservation, (3) only to be used if a definite answer is not possible,(4) disagree with reservation (5) definitely disagree). For example "in this lesson we do things so many times that I started doing them without thinking about it" (Habitual action); " to pass this lesson you need to understand the content" (understanding); "I often reappraise my experience so I can learn from it and improve for my next performance" (reflection); and " this lesson has challenged some of my firmly held ideas" (critical reflection). Using the same instrument, Leung and kember (2003) reported reliability estimates ranging from (0.58- 0.74) for the four subscales of the RTQ. The evaluation of the questionnaire involved a review of:

- The internal consistency of the four scales; and
- The capacity of each scale to identify variation within the sample;

The Reflective Thinking Questionnaire RTQ was adapted by the researcher.

A five-point Likert scale was used for the questionnaire, the options A, B, C, D, E on the Likert scale, ranged from “definitely agree” (scoring5), “agree with reservation”(scoring 4), “only to be used if a definite answer is not possible” (scoring 3),“disagree with reservation” (scoring 2) and “definitely disagree” (scoring 1). The mid-range response is “only to be used if a definite answer is not possible” (scoring 3).

3.5.3 Mole Concept Construction Test (MCCT)

The MCCT was used to determine the experimental group student’s ability to construct a concept map. The instrument was adapted from Novak (1977).The construction test items comprised 25 concepts, all from mole concept in which students are expected to construct a concept map by linking or showing the relationship that exist between the 25 concepts listed. For example(see Appendix D).

3.5.3.1 Concept Map Scoring Rubric

Researchers have determined concern about concept map scoring systems and their connected validity and reliability. Generally, reliability data reported in studies using concept maps are in the form of interrater reliabilities (Ruiz-Primo &Shavelson, 1996)

The Researcher used an expert concept map (Appendix G) as a standard or reference material and a scoring rubric (Appendix F) to oversee students when constructing concept maps. The scoring rubric used to combine the qualitative analysis of framework structure and the quantitative analysis of links, in order to provide a valuable tool to highlight the key characteristics of concept maps. Kinchin,Hay and Adam (2000) classification put forward the qualitative "spoke-chain-net" to describe the radical changes in a concept map. In addition, the degree of valid crosslink age, the amount of branching and the hierarchical structure are included in the analysis because they reflect associative and super ordinate-subordinate categorical relationships among concepts. The concept maps have three dimensions of quantitative analysis: The links' validity, convergence and salience. McClure, Sonak and Suen (1999) expressed that links in the map is the most reliable scoring way.

In the scoring rubric, each proposition is scored from zero to three; if any of the essential concepts were missing, the students' knowledge of the concepts could not be determined. Students then received a score of zero and zero is assigned to invalid links, the links that were constructed based on false knowledge. The link that connects interrelated concept is assigned one but that misses the label. The link that is scientifically correct is two point and has a possible label indicated, but does not explicit the direction. If students had all of the pertinent links and correct answer concepts somewhere on their map, they received a score of 3 that is, nothing was missing. The correctly labeled links with the directions clearly by an arrow is three points.

Convergence measures the extent to which the possible links are actualized in the students' maps. The convergence score is computed as the number of the valid links in a map divided by the number of all possible links as derived from the expert map. Finally, salience measures the number of valid links. Salience is computed as the number of valid links divided by the number of all links in a student's map (BouJaoude&Attieh, 2008). This result compares very favorably with those reported in the literature on scoring concept maps (Ruiz-Primo &Shavelson, 1996).

3.5.4 Validation of the Instruments:MCPT, RTQ and MCCT

The test items in MCPT, RTQ and MCCT were given for validation. The complete test items were given to one experienced chemistry teacher in the secondary school who is a seasoned examiner of WAEC and NECO, two science educators who are well experienced in concept map construction from Science Education Department and a lecturer from Psychology, Ahmadu Bello University, Zaria, for comment on the validity and correctness of the questions. All of these educators are senior lecturers with the minimum qualification of PhD. Those involved in the validation were requested to critically examine and assess all the items of the instrument paying attention to the following:

- whether the test conformed to the subject specification
- whether the questions are clear, precise and free from ambiguity
- whether the questions match the ability of the students and
- whether the language of expression is simple and unambiguous for students understanding.

The experts made constructive criticisms in area of language level and content area of all the instruments used. The corrections were made leading to the final acceptance of the instruments that was used for the study. The instruments were also pilot tested.

3.6 Pilot Testing

The instruments (MCPT) and RTQ were pilot tested on a random sample of 49 students selected from (SS2) in GGSS Samaru to determine the appropriateness of the two instruments. The pilot testing also enables the researcher to determine the appropriate timing for each test as well as identify any problem which may affect the effective administration of the instrument during the actual research work. The result of the pilot test was used to calculate the reliability coefficient of the test as well as determining the item analysis of the test items. The difficulty indexes (*p*) determine whether to reduce or increase the test items. The spit-half method (odd and even serial number) was used to test the reliability of the test scores. The reliability of the instrument Mole Concept Performance Test (MCPT) was determined using Pearson Product Moment Correlation Formula, while the reliability of Reflective ThinkingQuestionnaire (RTQ) was determined using Cronbach Alpha Reliability Coefficient.

3.6.1Reliability Coefficient of Mole Concept Performance Test (MCPT)

The split-half method (odd and even serial numbers) was used to test the reliability of the test scores on 49 students who did not form the sample of the study. The test was administered once to 49 science students from GGSS Samaru,Kaduna state. The test scores were then split into two equivalent halves. The scores of the two halves were correlated and Pearson Product Moment Correlation Coefficient was used to determine the reliability of the instrument. From the result obtained, r was calculated and found to be 0.89, indicating a strong positive relationship. Thus, the instrument is reliable to measure the academic performance of the study subjects.

3.6.2ReliabilityCoefficient of Reflective ThinkingQuestionnaire (RTQ)

The internal consistency of the four scale (habitual action,understanding,reflection and critical reflection) of students QRT was determine during pilot testing. The scores obtained were computed into SPSS package to determine the cronbach alpha coefficient. The CronbachAlpha was deemed suitable for measuring the reliability of RTQ because it is used when we have multiple-scored items. The reliability estimates of RTQ ranges from 0.59-0.81 for the four sub scale(habitual action,understanding,reflection and critical reflection) of the RTQ which is in line with the findings of (Kember et al 2000)

3.6.3Items Analysis ofMCPT Instrument

The item analysis of a test item is concerned with evaluation of responses to each item in a multiple-choice so as to ensure that the test items are valid. It is in line with this that the facility index and discrimination index were determined for the purpose of standardization of the instrument Mole Concept Performance Test (MCPT).

3.6.3.1Facility Index

The facility index of an item indicates the percentage of subjects that got an item right(Furst,Grunlund,Williams and Lehmand, in Mahmud (2009).The following are the steps to follow in computing the facility index for each items in the test,viz:

- Rank the scores on the test from highest to lowest
- Identify the high scoring group and the low scoring group
- Identify one third of the top scoring group and one third of the bottom scoring group
- Determine the percentage of high scores of each item

- Compute the item facility index by adding the percentage of those correct in low scoring and high scoring and then divide by the number of students involved in the analysis.

The formula is F.I= $\frac{U+L}{N}$

F.I==Facility index

N== Number of students involve in the analysis

U== Number of students who passed the item in the upper percent.

L== Number of students who passed the item in lower percent

Facility index of 75% or higher is regarded as easy in terms of facility level, whereas an index of 25% or less is regarded as hard in terms of facility level. For this study,Mole Concept Performance Test (MCPT) with facility index of 42% falls within the range of (30-70)% was adopted for this study which is in line with James (2000) and Usman(2008).

3.6.3.2Discrimination Index

The discrimination index of a test is a measure of its ability to discriminate between high and low achievers as a whole (Furst,Grunlund,Williams and Lehmand, in Mahmud (2009).This was used to identify high and low achieving students. The difficulty index of test items is its ability to separate the high and low ranking students in a test. The calculation was done using scores of top twenty five 25% and bottom twenty five 25% of the total respondents. This was calculated using the formula given by Furst (2000) in Olorukooba,(2001).

$D_1 = \underline{Ru - Rl}$

½N

Where:

D=discrimination index

Ru=Number among upper 25% of respondents

Rl= Number among lower 25% of respondents

N=Total number of respondents

Items showing little or no difficulty or items that show percentage of success in favour of the poor group should either be eliminated or re-examined for vagueness and ambiguity and such items should be re-worded. Discrimination index for each item is calculated by subtracting the number of students in the lower group who answered the item correctly from the number of students in the upper group who got the items correctly. The answer is divided by half number of students in both groups by the number of student in one of the groups.

The discrimination index which ranges between 30% and 70% is regarded as moderately positive and is accepted for present study. This was used in selecting the final items of the test (MCPT).

3.7 Administration of Treatment

The experimental group students were taught mole concept using concept-mapping strategy while the control group students were taught mole concept using lecture method.

3.7.1 Teaching the Experimental Group

The experimental group was taught mole concept using the concept mapping strategy. This strategy is based on the constructivist view of learning where learners take active role in learning to ensure meaningful learning. Three stages were used in the delivery of the lessons using the concept mapping strategy:

1. **The Introductory Stage:** At this stage students were oriented on concept mapping. During the orientation, the hierarchical arrangement of concepts and propositions was discussed whether they are valid or not

2. **The Presentation Stage:** At this stage the major and sub concepts of the topics were written on the board. This was followed by explanation of the behavioral objectives and concept map illustrations of the ideas. During this period the students were engaged in a discussion involving questioning and answering of questions and expression of opinions. This helped student to have a clear view and understanding of the topics taught. Concepts ere explained to students using concept maps.

3. **The Practical Stage:** At this stage students were asked to construct their own concept maps individually using pencils. The students were provided with sheets of paper to construct the concept map. During the exercise, I went round to guide students who may have some difficulties. Students were given homework to do.

Introduction of Teacher to Students

↓

Students Orientation on Concept Mapping Strategy

↓

Introduction of the Topic and Behavioral Objectives of

the Lesson Explained to the Students

↓

Teacher: Prepare by developing list of key concept for the lesson

- Initiates concept mapping activity by eliciting key concepts from
  Students based on reading assignment, class activities or students prior knowledge.

- Use chalkboard or whiteboard to create initial concept map

↓

Students :Offer suggestion to the teacher in terms of :-

- Concept to add or delete
- Links expressed as propositional relationship between two or more concepts
- Arrows that represent flow of ideas
  *Teache*r: Uses basic operations to construct, edit, refine concept map based upon students input.

↓

*Students' Activities :*students construct concept map in groups where they share ideas

↓

Students Activities: Students construct concept map individually

Teacher: Evaluatesstudent's concept map

Fig 3.2: Flowchart for concept mapping strategy
Source: Adapted from Vitale and Romance (1992)

On the first lesson, the students were introduced to concept mapping by the researcher using the orientation plan(Appendix E week one) as a guide. Sub topics considered were explanation on stoichiometry, chemical quantity and their units and mole concept. The lessonended with concept mapping exercise. Students were grouped and given a focus question with list of concepts, and sheets of paper to construct concept maps. Groups submitted their maps for scoring after the exercise.

On the second lesson, the sub heading under stoichiometry explainedwere morlarity,molar mass, mass concentration, amount and Avogadro's number. The students' previous knowledge was reviewed before treating the sub- topics of the day. Students were made to construct concept maps in groups and submitted at the end of the exercise. On the third and fourth lesson, series of numerical questions on stoichiometry were asked by the researcher. Both the researcher and the students solved the problems using the mole concept. Students asked questions. Both exercises and homework were given to the students. Student constructed concept map individually to show the relationship that exist between these concepts; molar concentration, mass concentration, molar mass, amount, Avogadro's number.

On the fifth lesson, percentages of element/atom present in a compound were calculated. Summary of the general lesson was given. On this same day, the experimental group was post tested with (MCPT and MCCT). On the sixth day both the control group and the experimental group were given RTQ to fill. The students got a better understanding of the questionnaire through the researcher's explanation of each items. The lesson plan served as a guide during teachingS. (See Appendix F)

3.7.2 Teaching the Control Group Using Lecture Method

The control group was taught the same content and in the same sequence as the experimental group. However, they were taught using the lecture method. The lecture method involves teaching topics in a regular chemistry class where teaching and learning activities are mainly teacher-centred. The researcher taught using her prepared lesson plan and notes (See Appendix G) and does most of the talking during the teaching process. The researcher explained concepts to students followed by writing main ideas on the board for students to copy. Each lesson ended with summary.

3.8 Procedure for Data Collection

During the familiarization, the experimental group and the control group were pretested. The test comprised items on the topic stoichiometry. The pretest was to ascertain the homogeneity of the experimental and control groups, and also to ascertain the level of knowledge each group has on Mole concept before treatment is given. Time allocation for the pretest was 30 minutes. The researcher invigilated Students in order to ensure that they do independent work. The students answer sheet was marked using the marking scheme (Appendix B). After the interventions to both the experimental and the control groups, they were given the same Mole Concept Performance Test (MCPT) administered in the pretest, as the posttest. The experimental group was tested on concept map construction using the Mole ConceptConstruction Test (Appendix C). The test was to compare the males and females in their ability to construct concept map. After the tests, the control and the experimental group were given the questionnaires to respond to. The scores of Mole Concept Performance Test, Reflective Thinking

Questionnaire and Mole Concept Construction Test were collected and recorded for both experimental and control group for analysis.

3.9 Procedure for Data Analysis

The scores collected were statistically analyzed to answer the research questions and test the hypotheses. The research questions were answered by descriptive statistics, that is, mean deviation and standard deviation while sixhypotheses were statistically tested. The following hypotheses were formulated in chapter one to answer the research questions at 0.05 level of significance: Here were the stated hypotheses and the statistical test that wasused,viz:

$H0_1$: There is no significant difference between the mean scores of students exposed to concept mapping strategy and those taught by lecture method.

t-test was used for analysis at 0.05 level of significance

$H0_2$: There is no significant difference between reflective thinking mean rank of student when exposed to concept mapping teaching strategy and those taught by lecture method.

Mann-Whitney U test statistics was used to analyze the hypothesis at 0.05 level of significance.

$H0_3$: There is no significant relationship between students' mean scores and reflective thinking mean rank when exposed to concept mapping teaching strategy. Spearman- Rank Correlation (Rho)was used to find the relationship which exists between students' academic performance and level of reflective thinking at 0.05 alpha levels.

$H0_4$: There is no significant difference between the academic performancemean scores of male and female students when exposed to concept mapping teaching strategy.t-test was used for analysis at 0.05 level of significance

$H0_5$**:** There is no significant difference between the reflective thinking of male and female students when taught using concept mapping strategy.

Mann-Whitney U test statistics was used to analyze the hypothesis at 0.05 level of significance.

$H0_{6:}$ There is no significant difference between male and female students ability to construct a concept map.t-test was used for analysis at 0.05 level of significance

All the data collected were entered separately into SPSS 21.0 for data output.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

In this chapter the result of data collected during the research and their discussions were presented. The data collected were analyzed using the Statistical Package for Social Sciences (SPSS) version 21.0 and the level of significance for retaining or rejecting the stated hypothesis was 0.05 at 95% significance level. The chapter also contain summary of the findings obtained from the results.

4.2 Data Analysis and Results

Four types of data were collected from the study which includes**:**

1. Performance scores from the pretest
2. Performance scores obtained from the posttest
3. Students' scores from reflective thinking questionnaire before and after the study.
4. Students' scores from concept mapping construction after treatment.

The two groups of students that were used for data collection are the experimental group and the control group. Three instruments were used for data collection, they were:-

1. Mole Concept Performance Test (MCPT)
2. Reflective Thinking Questionnaire (RTQ)
3. Mole Concept Construction Test (MCCT)

4.3 Answering Research Questions and Testing Null Hypotheses

Research Question One

What is the difference between mean scores of chemistry students taught using concept mapping strategy and those taught using lecture method?

To provide an answer to this research question, the mean standard deviation scores of students taught using concept-mapping strategy and those taught using lecture method of teaching in Mole Concept Performance Test (MCPT) was used. The analysis is as shown in Table 4.1

Table 4.1Posttest Mean Scores of the Experimental and Control Group Based on Performance.

Group	N	Mean	Std. Deviation	Mean difference
Experimental	37	67.36	14.17	10.97
Control	39	56.39	12.37	

From Table 4.1, it can be seen that the mean score of experimental group students taught using concept- mapping strategy is higher than the mean score of the control group students taught using lecture method with a mean difference of 10.97. Therefore there is a difference in the performance of experiment group exposed to concept-mapping strategy and the control group taught using lecture method. This means that concept mapping enhance students' academic performance in chemistry. To find out how significant the difference is, t-test statistics was used in analyzing the scores.

Null Hypothesis One

HO_1: There is no significant difference between the mean scores of students taught using concept-mapping strategy and those taught using lecture method.

To test this hypothesis, the posttest mean scores of experimental and control groups students were analyzed using the t-test statistics. The result of the t-test analysis is shown in Table 4.2.

Table 4.2 Posttest t-test of Experimental and Control Group Based on Academic Performance

Group	N	Mean	Std. Deviation	Std.Error mean	df	t.cal	t.crit	p-value
Experimental	37	67.36	14.17	2.16	74	4.20	2.00	0.02*
Control	39	56.39	12.37	2.06				

*Significant at p<0.05 level

Table 4.2 shows that the t.cal of 4.2 is greater than the t.crit of 2.0 and the p- value observed was 0.02 at the degree of freedom of 74 and 0.05 level of significance. The p- value of 0.02 is less than the alpha value of 0.05 which is an indication that there is significant difference in the performance of students taught chemistry using concept-mapping strategy and those taught using lecture method. The mean score of the experimental group as shown in Table 4.2 is 67.36 which is higher than 56.39 mean score of the control group. This indicates that the experimental group students taught using concept-mapping strategy performed better than the control group students taught using lecture method.

Based on the result of Table 4.2, the hypothesis which states that there is no significant difference in the academic performance of students taught using concept-mapping and those taught using lecture method is therefore rejected. There is significant difference in the performance of students taught using concept-mapping and those taught using lecture method in favour of those taught using concept-mapping strategy.

Therefore, concept-mapping strategy is found to be more effective in improving student’s performance than the lecture method.

Research Question Two

What is the difference in students’ reflective thinking mean rank between those taught using concept mapping strategy and lecture method.

Table 4.3 Posttest Reflective Thinking Mean Rank and Sum of Rank of Experimental and Control Group

Groups	N	Mean Rank	Sum of Rank	Mean Rank Difference
Experimental	37	68.42	1261	
				10.10
Control	39	58.32	872	

Table 4.3 shows that the mean rank value of (68.42) was obtained in the experimental group with a value of (1261) as sum of rank which is higher than the mean rank value of the control group (57.32) with sum of rank of (872).A mean rank differenceof (10.10)was obtained and this shows that the experimental group students taught using concept mapping strategy developed a higher level of reflective thinking in mole concept than the control group students taught using lecture method. This means that concept mapping strategy enhanced students' reflective thinking in mole concept. To find out how significant the difference is, the scores were subjected to Mann-Whitney U-test statistics.

Null Hypothesis Two

HO_2 : There is no significant difference between reflective thinking mean rankof students taught using concept-mapping strategy and those taught using lecture method.

Table 4.4 Mann-Whitney U-test Analysis of Reflective Thinking Level of Students in Experimental and Control Groups

Group	N	Mean Rank	Sum of Rank	Mann-Whitney U-test	P value	Decision
Experimental	37	68.42	1261			
				32	0.05	Sig*
Control	39	58.32	872			

*Significant at p $\leq$0.05 level

Table 4.4 shows that the mean rank value of 68.42with sum of rank of 1261was obtained by the experimental group. On the other hand, the mean rank value of 58.32with sum of rank of .872 was obtained by the control group .The Mann-Whitney U value was 32.The P-value of 0.05 obtained is equal to the 0.05 level of significancewhich is an indication that there is significant difference between the experimentalgroup and the control group. This shows that the students in the experimental group achieved higher than the students in the control group in Reflective Thinking Questionnaire. This indicates that concept-mapping strategy enhanced students' reflective thinking better than the students taught using lecture method.

Based on the result of Table 4.4, the hypothesis which states that there is no significant difference in the reflective thinking mean rank of student taught using concept-mapping and those taught using lecture method is therefore rejected. There is significant difference in reflective thinking mean rank of students taught using concept-mapping and those taught using lecture method in favour of those taught using concept-mapping strategy.

Therefore, concept-mapping strategy was found to be more effective in improving students' reflective thinking than the lecture method.

Research Question Three

What is the relationship between students' mean scores and reflective thinking mean rank when taught using concept mapping strategy.

Table4.5 Posttest Mean and Standard Deviation of Students' Academic Performance and Reflective Thinking.

Variable	N	Mean	Std. deviation	Mean difference
Academic performance	37	68.02	2.2	
				0.56
Reflective thinking	37	68.58	2.7	

Table 4.05 showed that the academic performance mean score of 68.02 is less than the reflective thinking means score of 68.58 with a mean difference of 0.56.Hence there is a difference between academic performance and reflective thinking of students when taught using concept mapping strategy. However to determine whether a significant relationship exist, Spearman Rank Correlation Coefficient (Rho) was used.

Null Hypothesis Three

HO_3 : There is no significant relationship between students' mean score and reflective thinking mean rank of students taught using concept-mapping strategy.

To test this hypothesis, the posttestmean scores of experimental group were analyzed using the Spearman Rank (rho) statistics. The result of the Rho analysis is shown in Table 4.6

Table 4.6 Results of Spearman Rank Correlation Between Students' Academic Performance and Reflective Thinking.

Variables	N	Mean	Std dev.	df	r-cal	r-crit	P	Decision
Academic performance	37	68.02	2.2	72	0.35	0.25	0.04	Sig*
Reflective thinking	37	68.58	2.7					

*Significant at p<0.05

Table 4.6 revealed that r-calculated of 0.35 is greater than critical value of 0.25 at 0.05 level of significance, it can be seen that a correlation coefficient value of 0.35 was observed.Since the p value of 0.04 is less than the 0.05 confidence level, the correlation is therefore significant The r-value was positive, it indicated that there is positive relationship between academic performance and reflective thinking (r= +0.35).The positive value of 0.35 relationship implies a weak correlation between students' academic performance and reflective thinking. Therefore the hypothesis that states there is no significant relationship between academic performance and reflective thinking is thereby rejected. This indicated that when students' reflective thinking is high, it enhances the academic performance. Likewise, decrease in reflective thinking will lower students' academic performance. In other word, concept mapping strategy is a teaching method that enhances students' academic performance and reflective thinking in chemistry. It gave students the opportunity to reflect on the relationship between the different concepts before linking them. This act of linking the concepts helped and improved the reflective thinking ability of the students in the experimental group.

Research Question Four

What is the difference between the mean scores of male and female students taught using concept- mapping strategy.

The data collected for the purpose of answering research question four was analyzed using descriptive statistics in form of mean and standard deviation as shown in Table 4.7

Table 4.7 Posttest Mean and Standard Deviation of Students' Performance According to Gender in the Experimental Group

Gender	N	Mean	Std. Deviation	Mean Difference
Male	19	37.71	2.34	
				0.35
Female	18	38.06	2.37	

From Table 4.7 the mean scores of the male and female students are (37.71 and 38.06) respectively with a mean difference of 0.35. The femalestudents achieved higher than the male students. To find out if the value is significant, t-test statistics was used.

Null Hypothesis Four

HO_4: There is no significant difference between the mean scores of male and female students when taught using concept-mapping strategy.

To test the hypothesis, the posttestperformance meansscores of male and female students in the experimental group were analysed using t-test statistics. The result of the t-test analysis is as shown in Table 4.8

Table 4.8 Posttest t-test of the Performance of Experimental Group According to Gender

Gender	N	Mean	S.D	Std. error mean	df	t-cal	t-crit	p-value
Male	19	37.71	2.34	1.16	35	0.54	2.04	0.93
Female	18	38.06	2.37	1.19				

Not Significant at p>0.05

From Table 4.8 the calculated t value of 0.54 is less than the critical value of 2.04 at the degree of freedom of 35 at 95% confidence level. The obtained p-value of 0.93 is greater than 0.05 significantlevel. This result indicates that there is no significant difference in the performance of male and femalestudents when taught chemistry using concept-mapping strategy. By implication male and female studentsperformed equally the same when exposed to concept mapping strategy. The null hypothesis is therefore retained.

Research Question Five

What is the difference between reflective thinking exhibited by male and female students taught using concept-mapping strategy.

The data collected for the purpose of answering research question five was analysed using descriptive statistics inform of mean rank and sum of rank as shown in Table 4.9

Table4.9Posttest Mean Rank and Sum of Rank of Students'Reflective Thinking According to Gender in the Experimental Group.

Gender	N	Mean Rank	Sum of Mean Rank.	Mean Rank Difference
Male	19	47.86	974	
			0.19	
Female	18	48.05	1102	

From Table 4.9 the mean rank and sum of rank of the male and female are (47.86 and 974)and (48.05 and 1102) respectively with a mean rank difference of 0.19.The female achieved higher than the male. To find out how significant the difference is, Mann-Whitney U -test statistics was used.

Null Hypothesis Five

HO_5: There is no significant difference between the reflective thinking of male and female students taught using concept mapping strategy.

Table 4.1.1 Mann-Whitney U-test of Students Reflective Thinking According to Gender in The Experimental Group

Gender	N	Mean Rank	Sum of Rank	Mann-Whitney U-test	p-value	Decision
Male	19	47.86	974			
				-44	0.72	NS
Female	18	48.05	1102			

Not Significant at P>0.05

Table 4.1.1 revealed that the Mann Whitney U- value is -44. The obtained p-value of 0.72 is greater than 0.05 significantlevel. This result indicated that there is no significant difference in reflective thinking of male and female when taught chemistry using concept-mapping strategy. By implication male and female students perform equally the same when exposed to concept mapping strategy. The null hypothesis is therefore retained.

Research Question Six

What is the difference between male and female students' ability to construct a concept map?

The data collected for the purpose of answering research question six was analysed using descriptive statistics in form of mean and standard deviation as shown in Table 4.1.2.To provide an answer to this research question, the result in Mole Concept Construction Test was used, the analysis is as shown in Table 4.1.2.

Table 4.1.2 Posttest Mean and Standard Deviation of Student's Performance According to Gender inConstruction Test

Gender	N	Mean	Std. Deviation.	Mean Difference
Male	19	63.62	2.73	
				0.41
Female	18	64.03	2.91	

From Table 4.1.2 the mean score of the male and female are (63.64 and 64.07) respectively, with a mean difference of 0.41.The female achieved higher than the male in the construction test. This indicates that the means difference of (0.41) exists. However, to find out how significant the difference is, t-test statistics was used.

Null Hypothesis Six

HO_6 :There is no significant difference between male and female students' ability to construct a concept map.

Table 4.1.3 Posttest t-test of Students' Construction According to Gender in the Experimental Group

Gender	N	Mean	Std.deviation	Std. error mean	df	t-calt-crit		p-value
Male	19	63.62	2.73	2.97				
					35	-4.3	2.04	0.92
Female	18	64.03	2.91	3.08				

Not Significant at P>0.05 level

From Table 4.1.3 the calculated t value of -4.3 is less than the critical value of 2.04 at the degree of freedom of 35 at 95% confidence level. The p-value of 0.92 is greater than 0.05 significant level. This result indicates that there is no significant difference between the performance of male and female students'ability in constructing a concept map. In other word,male and female students perform equally the same in the mole concept mapping test. The null hypothesis is therefore retained.

4.4 Summary of Major Findings

The summaries of the findings from the results are as follows:

1. Students in experimental group taught using concept- mapping strategy achieved significantly higher than the subjects in the control group taught using lecture method

2. There was significant difference between the reflective thinking of students taught chemistry using Concept mapping strategy and those taught chemistry using lecture method in favour of the experimental group..

3. Concept mapping strategy is gender friendly since there was no significant difference in the academic performance of male and femaletaught chemistry using Concept-Mapping Strategy.

4. There was no significant difference in the reflective thinking of boys and girls taughtchemistry using Concept mapping strategy.

5. There was a significant relationship between students' academic performance and reflective thinking of students taught chemistry using concept mapping strategy in a positive direction.

6. There was no significant difference between male and female students' ability to construct concept map.

4.5 Discussion of the Results

The Objective of this study was to investigate the effects of concept mapping `strategy on reflective thinking and academic performance in chemistry among secondary school students in Kaduna state, Nigeria. The results are discussed as follows:

The result from the research question and testing of hypothesis one indicated that the experimental group who were taught using Concept mapping strategy achieved significantlybetter than those in the control group who were taught same concepts using Lecture method. The significant difference in performance is in favour of the students in the experimentalgroup which suggested a greater effectiveness of Concept mapping strategy over the Lecturemethod of teaching. This finding is in conformity with that of Appaw (2011), Otor (2013), Jack (2014) who reported that students exposed to Concept mapping strategy significantly outperformed students exposed to traditional methodof teaching. In similar works by Cheema and Mirza (2013), students taught using concept map had significantly achieved higher than their counterparts taught with the traditional method. Students improved performance might be that the instructional strategy provides opportunity for students to- link concepts learned. Concept mapping strategy enable students to establish a relationship between concepts learned thereby increasing performance. The students in the experimental group were able to see links among concepts and this boosted their comprehension on topics which they were taught

The result of the students in the control group showed that lecture method is not very effective in promoting meaningful learning and increasing academic performance. As students in lecture method are engaged as passive learners. This is in line with the argument of Stein horst and Keeler, 1995 that traditional Lecture method has a tendency to view students as passive learners because it does not engage them actively. The finding from this study indicated that Concept mapping strategy can enhanceacademic performance among students and yield better result than

Lecture method. Students in the concept mapping group might have learnt meaningfully because of the hierarchical, logical and sequential presentation of concepts. Ausubel (as cited in Novak &Canas, 2008) asserted that, for meaningful learning to occur the new ideas must have potential meaning and the learner must possess relevant concepts that can anchor new ideas. The learner must also consciously relate the new ideas or verbal propositions to relevant aspects of their current knowledge structure in a conscious manner. According to Ausubel (1984) meaningful learning occurs by the process of subsumption when potentially meaningful propositions are subsumed.

The results from the descriptive statistics and hypothesis two showed significant difference in the reflective thinking of the experimental group exposed to Concept mapping strategy and the control group exposed to Lecture method. The significant difference is in favour of the experimental group as shown in Table 4.4. The result showed a change in the reflective thinking of students taught using Concept mapping strategy in the experimental group compared to those taught using Lecture method in the control group. The differences in the reflective thinking of students could be linked with the instructional strategy that was used to teach students the concepts in chemistry. This is because concept mapping strategy is a teaching method that enhances students' reflective thinking in chemistry. It gave students the opportunity to reflect on the relationship between the different concepts before linking them. This act of linking the concepts helped and improved the reflective thinking ability of the students in the experimental group compared to the control group where students taught using lecture method are passive listeners.

This finding is in line with that of a study conducted by Mason (1992) who stated that concept mapping strategy develops students' reflective thinking. Concept mapping strategy reduces the abstract level of concepts which enhance meaningful learning and reduced the difficulty in learning. Meaningful teaching which is employed by Concept mapping strategy help to improve reflective thinking of students in chemistry and subsequently enhance academic performance of students in the experimental group.

The result from testing the hypothesis three showed a significant relationship between academic performance and reflective thinking of students when taught mole concept using concept mapping strategy. By implication it means that an increase in students' reflective thinking enhances their academic performance while a decrease in reflective thinking leads to poor academic performance of students. The result in Table 4.6 further backed up the statement of Moon (1996) According to her meaningful learning consist of 5 cycles and it is only through reflection a student can move from one stage of the cycle to another for meaningful learning to occur. The ability of students to reflect during learning will bring about meaningful learning which by extension will improve students' academic performance.

Results from the research question and testing of Hypothesis four showed that there was no significant difference in the performance of male and female when exposed to Concept-mapping strategy. The t-test of the posttest scores revealed no significant difference in the performance of the male and female students as shown in Table 4.8 This means that Concept mapping strategy is an instructional strategy that is gender friendly as it gives equality in learning for both sexes. This finding is in line with the findings of (Otor, 2011) who reviewed researches in gender and Concept mapping strategy, His finding indicated that female students perform better than their male counterparts' taught using concept mapping strategy. However, there was no significant difference in their performance. This shows that both male and female students benefited equally when exposed to Concept mapping strategy

Results from the responses and testing of Hypothesis five showed that there was no significant difference in the reflective thinking of male and female when exposed to Concept-mapping strategy. The t-test of the posttest scores revealed no significant difference in the reflective thinking level of male and female as shown in Table 4.1.1. This shows that boys and girls benefited equally when exposed to Concept mapping strategy

The result shown in Table 4.1.2 indicated that the female student were able to construct concept map better than their male counterparts, though there was no significant difference in both sex ability to construct a concept map on mole concept this is in line with the findings of Larbi (2011) who revealed that both male and female students constructed concept map alike. Some males construct good concept maps while some constructed bad ones. Also some females constructed good concept maps while some also constructed bad ones.

It can be said that the ability to construct good concept maps is not restricted to gender. This study is also in line with Bello and Abimbola (1997) who also reported that the ability to construct good concept map is not limited to a student's gender. As student construct concept maps, it helps them to summarize, organize and present ideas logically. Since construction of concept mapping is idiosyncratic, it will help students to create their own knowledge to enhance understanding of content in chemistry.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1Introduction

In this chapter the summary of the study were presented. The summary of the findings, conclusion from the findings and recommendations arising from the study were discussed. The limitation of the study and suggestions for further studies were also outlined.

5.2Summary

The study was conducted to determine effects of Concept mapping strategy on the reflective thinking and academic performance in mole concept among secondary school students in Kaduna state. To achieve these, two groups of students were formed; one of the groups the experimental group was exposed to Concept mapping strategy and the other group the control group was exposed to lecture method. The effects of the methods in academic performance and reflective thinking were deduced.

The sample size for the study comprised a total of 76 Senior Secondary two (SSII) Students drawn from two Secondary Schools in Zaria, Kaduna State. The Government Secondary School Jama'a served as the experimental group and the students were taught Mole concept using concept mapping and Government Secondary School Bassawa was used as control group and the students were taught the same concept using lecture method.

Three instruments were used;Mole Concept Performance Test, a 30 item multiple choice instrument, Reflective Thinking Questionnaire and Mole Concept Construction Test. Six null hypotheses were tested to answer the stated research questions. The study adopted a pretest – posttest Quasi Experimental-Control Group design. The treatment for the study involvedteaching the experimental groups mole concepts in chemistry using Concept mapping strategy and teaching the control groups same mole concepts using Lecture method.

A pretest was administered to the experimental group and the control group before commencement of treatment. The treatment lasted for six weeks after which a posttest was administered to both the experimental group and the control group. The Questionnaire for reflective thinking was also administered to the two groups while mole concept construction test was administered to the experimental group only. The data generated were analyzed according to the stated hypotheses. The data was analyzed using t-test statistics, Mann-Whitney and Spearman Rank Correlation Coefficient with the help of SPSS Statistical version 21.0. The confidence level of $p \leq 0.05$ was adopted for retaining or rejecting the hypotheses.

5.3 Summary of Major Findings

The major findings from the studywere as follows:

1. Students in experimental group taught using concept- mapping strategy achieved significantly higher than the subjects in the control group taught using lecture method

2. There was significant difference between the reflective thinking of students taught chemistry using Concept mapping strategy and those taught chemistry using lecture method in favour of the experimental group..

3. Concept mapping strategy is gender friendly since there was no significant difference in the academic performance of male and femaletaught chemistry using Concept-Mapping Strategy.

4. There was no significant difference in the reflective thinking of boys and girls taughtchemistry using Concept mapping strategy.

5. There was a significant relationship between students' academic performance and reflective thinking of students taught chemistry using concept mapping strategy in a positive directionusions were drawn.

5.4 Conclusion

1. When students were taught mole concept using Concept -mapping strategy, it was found to improve the performance of Senior Secondary School Students in Chemistry.
2. The use of Concept mapping strategy improved the Reflective Thinking of Senior Secondary School Students in Chemistry.
3. Concept Mapping Strategy is more effective in increasing the performance of Senior Secondary School Students in chemistry than the Lecture Method.
4. Concept mapping strategy is more effective in improving the reflective thinking of Senior Secondary School Students in chemistry than the Lecture Method.
5. Concept- mapping strategy is gender friendly since both gender showed improved performance.
6. Concept- mapping strategy helps to improve the reflective thinking of both boys and girls in chemistry.

5.5 Contributions to Knowledge

The concern of this study was to investigate the effects of concept-mapping strategy on reflective thinking and academic performance in mole concept among secondary school students .The findings of this study have significant contribution and great implications for educational practices.

The following contributions to knowledge were made:

1. The researcher was able to establish that students taught mole concept using Concept mapping strategy had significant academic performance mean scores regardless of gender.

2. Concept mapping as an instructional strategy helped in improving the reflective thinking of chemistry students regardless of gender.
3. This research study also shows Concept Mapping Strategy is gender friendly. The finding shows that there is no significant difference in performance of boys and girls when taught mole concept using concept mapping strategy. This means employing Concept Mapping Strategy help to minimize gender difference in the chemistry class.
4. One of the finding in this study shows that there is a positive relationship between academic performance and reflective thinking which can further be explained that for meaningful learning to occur, students should be able to reflect which by extension enhances students' academic performance in chemistry.
5. The researcher developed mole concept performance test which could be used by other researchers in future.

5.6Recommendations

The following recommendations were made:

1. Lecture method in this research study has been found to be less effective in improving the academic performance of students. Therefore science teachers should look for alternative and more effective means of instruction to avoid poor performance of their students.
2. Concept mapping strategy has been shown to improve academic performance for both sexes; therefore teachers should be advised to adopt the approach in teaching.
3. The Federal and State Ministries of Education through Nigerian Educational Research and Development Council (NERDC) Kaduna branch should provide adequate- funds for training of science teachers in-form of seminars, workshops and conferences that

focuses on Concept mapping strategy and other teaching strategies that are more effective in promoting academic performance and reflective thinking.

4. Organizations such as Science Teachers Association of Nigeria (STAN), Nigerian Educational Research and Development Council and others should incorporate Concept mapping strategy in Science curricula at Senior Secondary School level to encourage use of the strategy among science teachers.

5. There is a need for curriculum planners and textbook publishers to take into cognizance Concept mapping strategy in developing the curriculum and the textbooks as context for each unit of learning must be identified. This will simplify adoption of the method for use by teachers.

5.7 Limitations of the Study

1. The schools used for this study were two Government Secondary Schools of Kaduna State which narrow the scope of generalizations of findings. Thegeneralization could not be extended to other schools in the State like Private Schools, Military Schools and Federal Government Schools.

2. The conclusions reached in this study are restricted to the effect of Concept mapping strategy on the teaching of mole concept at Senior Secondary Schools of Kaduna State.

3. The major weakness lies in some extraneous factors such as age, ability, maturation and previous learning experiences whichwere not controlled in this study.

5.8 Suggestions for Further Studies

1. The study should be replicated in other States of Nigeria and other Science Subjects to increase the scope of generalization.
2. There is a need for researches to be conducted on effects of other science teaching methods on students' reflective thinking at secondary schools using a different instrument in measuring reflective thinking.
3. The study can be extended to other levels of education to see if level is a factor in the Approach

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APPENDIX A

MOLE CONCEPT PERFORMANCE TEST (MCPT)

School……………………………………………….

Gender………………………………………………

Age ………………………………………………….

Instruction: Answer all the question by choosing the appropriate options (Letter)

1. Mole is a unit for

   (a) Mass(b) Molar mass (c) Volume (d) Amount (e) Molarity

2 The unit for Molarity is (a) Kilogram (b) Mass (c) Mole (d) $Moldm^{-3}$(e) Amount

3. The unit for Mass concentration is (a) Second (b) Mass (c) gdm^{-3} (d) Mole(e) $Moldm^{-3}$

4. The unit for molar mass is (a) $Moldm^{-3}$ (b) gdm^{-3} (c) $gmol^{-3}$ (d) gram(e) Mole

5. What do you need to know in order to find out the mass of a mole of any compound (a) Mass (b) Amount (c) Molar mass (d) Molarity(e) Volume

6. What is the mass concentration of 0.1M of $NaHCO_3$ (a)52.02 (b) 108.4 (c) 156.06 (d)8.4(e)5.0

7. The number of moles represented by 252.06g of $NaHCO_3$ is (a) 5.0 (b) 3.0 (c) 2.0 (d) 1.0(e) 108.4

   Calculate the molar mass for each of the following compounds

8. H_2SO_4 (a) 98 (b) 48 (c) 108 (d) 56(e) 104

9. $NaNO_3$ (a) 85 (b) 75 (c) 70 (d) 108(e) 84

10. Given the mass concentration of NaOHas 4.0g, what is it molarity? (a) 59.8 (b) 95.2 (c)40 (d) 0.1(e) 8.4

11. What is the mass of 1.50×10^{23} molecules of cane sugar ($C_{12}H_{22}O_{11}$)

    (a) 5.13g (b) 85.2g (c) 342g (d) 1370g(e) 94g

12. The sum of the atomic masses of all atoms in the formula unit of a compound is the (a) atomic density (b) molecular mass (c) Ionic mass (d)formula mass(e) 108.4

13. Which of the following unit is used to represent the chemical quantity of a substance as a number of particles? (a) Kilogram (b) Ampere (c) gross (d)Mole(e) gram

14. The number of moles represented by 23.0gram of nitrogen (iv) oxide NO_2 is (a) 0.5 (b) 1.5 (c) 1.0 (d) 2.0(e) 4.0

15. Which of the following statement explains why chemists do not count atoms and molecules directly?
    a. Matter is neither created nor destroyed in a chemical reaction
    b. All relationship in a chemical reaction can be expressed as mass ratios
    c. Atom and molecules are extremely small
    d. Reactions occur one at a time.
    e. None of the above

16. Given the molarity of Na_2SO_4 as 0.1M, what is the mass concentration (a)14.2 (b) 36.5 (c) 142.06 (d) 70.9(e) 138.4

17. The number of atoms of each element in a molecule is shown in (a)empirical formula (b) molecular formula (c) molecular mass (d) mole(e) mass

    Calculate the number of mole for each substance from each of the following masses given

18. 15.0g of carbon iv oxide, CO_2 (a) 0.34 (b) 0.50 (c) 1.52 (d) 0.71(e) 1.4

19. 50.0g of Aluminum Sulphate, $Al_2(SO_4)_3$ (a) 0.22 (b) 0.15 (c) 0.45 (d) 0.82(e) 10.4

    Calculate the percentage of copper, Cu, in the following compound

20. $CuSO_4$ (a) 35%) ()50% (c) 65% (d) 40%(e) 108%

21. CuO (a) 80% (b) 20% (c) 30% (d)75%(e) 84%

22. CuS (a) 60% (b) 66.7% (c) 76.7% (d) 75%(e) 108%

    What is the mass of each substance present in the following

23. 0.105 Moles of $Na_2C0_3.10H_2O$ (a) 7.0g (b) 30.0g (c) 15.6g (d) 2.4g(e) 4g

24. 0.2 mole of K0H solution (a) 10.5g (b) 7.6g (c) 11.2g (d) 12.5g(e) 10.4g

25. What is the atomic mass of sodium (a) 11 (b) 23 (c) 46 (d) 14(e) 14

26. What is the atomic mass of chlorine (a)15 (b)12 (c)17 (d)35.5(e) 40

27. Chlorine molecule contains……….atoms.(a)$6.02x10^{23}$ (b)$6.5x10^{23}$ (c)$12.0x10^{23}$ (d)$6.04x10^{23}$(e) $1.08x10^{4}$

28. Molar Concentration is the same as…(a)mass concentration (b)molarity (c)Density (d)Amount(e) Volume

29. The atomic number of Oxygen is… (a)16 (b)8 (c)32 (d)6(e) 104

30. The atomic number of Carbon is… (a)4 (b)6 (c)12 (d)23(e) 10

[Hint: C = 12, H = 1, O = 16, N = 14, Na= 23, Al = 27, Cu = 64, S = 32, K = 39]

APPENDIX B

MARKING SCHEME FOR (MCPT)

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

APPENDIX C

ITEM ANALYSIS OF MCPT TEST ITEMS

	$F.I = \frac{U+L}{N}$		$D_1 = \frac{Ru - Rl}{\frac{1}{2}N}$
1	0.28*	1	0.47
2	0.53	2	0.71
3	0.67	3	0.71
4	0.27*	4	0.57
5	0.49	5	0.68
6	0.31	6	0.57
7	0.49	7	0.49
8	0.59	8	0.69
9	0.47	9	0.53
10	0.55	10	0.62
11	0.35	11	0.53
12	0.59	12	0.66
13	0.39	13	0.69
14	0.38	14	0.69
15	0.38	15	0.65
16	0.39	16	0.70
17	0.39	17	0.70

18	0.43	18	0.66
19	0.22*	19	0.42
20	0.36	20	0.49
21	0.33	21	0.65
22	0.45	22	0.49
23	0.35	23	0.61
24	0.43	24	0.49
25	0.31	25	0.49
26	0.38	26	0.65
27	0.31	27	0.57
28	0.35	28	0.69
29	0.47	29	0.70
30	0.47	30	0.65

F= Facility index

D= Discrimination index

*= Items which were reconstructed

APPENDIX D

MOLE CONCEPT CONSTRUCTION TEST (FOR EXPERIMENTAL GROUP)

School……………………………………………….

Gender………………………………………………

Age ………………………………………………….

With the use of a concept map show the relationship that exists between the following Concepts.

1 Amount
2 Mole
3 Molar Mass
4 Mass
5 Molar concentration
6 Molarity
7 Mass concentration
8 Avogadors no
9 6.02×10^{23}
10 Molecules
11 No of mole
12 Ion
13 Atom
14 Mol
15 g/dm^3
16 mol/dm^3
17 gdm^{-3}
18 $moldm^{-3}$
19 M
20 g/mol
21 $gmol^{-1}$
22 Gram
23 Volume
24 $1000cm^3$
25 Elementary particles

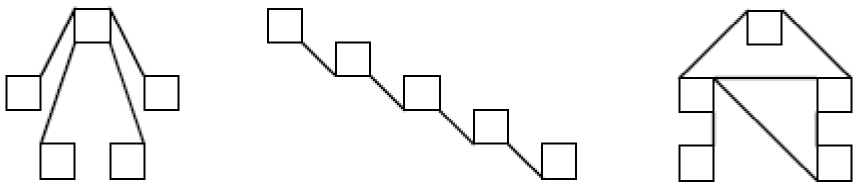
APPENDIX E

SCORING RUBRIC FOR CONCEPT MAP

Student name

1. Map Structure:

a. Spoke b. Chain c. Net



2. # of Correct Hierarchy levels: _______________

3. # of Correct Cross-Link:___________________

4. Quality of Propositions

Invalid proposition:________________x 0 = ______________

Possible relationship:______________x 1 = ______________

Correct-label proposition:___________x 2 = ______________

Directional correct proposition:_____ x 3 = ______________

5. Convergence Score =______________

6. Salience Score =______________

Total =_______________

APPENDIX F

LESSON PLAN: ORIENTATION FOR EXPERIMENTAL GROUP

Week	One
School	G.S.S.Jama'a (Snr)
Date	
Time	
Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Concept Mapping
Reference	
Material	
Behavioural Objectives	At the end of the lesson, students will be able to; a. Define concept map b. Give at least 2 characteristics of a concept map c. List at least 2 objectives of a concept map d. Construct a concept map
Previous Knowledge	Students are familiar with matching of items
Introduction	Teacher introduces the lesson by asking questions on the previous knowledge.
Presentation	Teacher presents the lesson in the following steps
Step 1	Teacher defines and explains concept map as follows: Concept map is defined as a graphical tool for organizing and representing relationships between concepts, indicated by a connecting line linking two concepts. Words on the line referred to as linking words or linking phases which specify the relationship between two concepts.

Step 2 Teacher lists all the characteristics of a concept map and it objectives

Concept mapping can be done for several purposes, some of which are:

- to generate ideas through brainstorming
- to design a complex structure
- to communicate complex ideas

to aid learning by explicitly integrating new and old knowledge

Characteristics of a Concept Map

1. Concepts are usually enclosed in a circle or a box.
2. Concept maps are represented in a hierarchical fashion, with the most general concept at the top of the map and the more specific concepts arranged below.
3. Another important feature of concept map is the inclusion of "cross-links" These are relationship (proposition) between concepts in different domains of the concept map.

Step 3 Teacher shows the students how to construct a concept map by illustrating it on the board giving some examples like matter

Step 4 Teacher summarizes the lesson to the students

Evaluation The teacher evaluates the students by asking the following questions

a. Define a concept map
b. List at least 2 characteristics of a concept map
c. List at least 2 objectives of a concept map
d. Construct a concept map showing the relationship between plant, seed, flower, root, air, green and water

Concept Mapping Method; Lesson Plan 2

Week Two

School

Date

Time

Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Concepts in Stoichiometry
Sub Topic	- Chemical Quantities - Units of Chemical Quantities - Mole concept
Reference Material	Ojokuku, G.O. *Practical Chemistry for Schools and Colleges Gbabeks* Publishers Limited, Ibadan
Behavioural Objectives	At the end of the lesson students will be able to; 1. Define stoichiometry of a chemical reaction 2. List chemical quantities 3. Give the units of chemical quantity 4. Define and explain mole concept 5. Construct a concept map of concepts listed
Previous Knowledge	Students are familiar with chemical symbol, compound and how to write chemical equation
Introduction	Teacher introduces the lesson by asking questions based on the previous knowledge and refresh their knowledge on concept map by giving a chart on the concept map of matter.
Presentation	Teacher present the lesson in the following steps
Step 1	Teacher explains the objectives of the lesson
Step 2	Teacher defines and explain stoichiometry of a chemical reaction and Mole concept
Step 3	Teacher mentions some chemical quantities with their units to the students.
Step 4	Teacher illustrates on the board

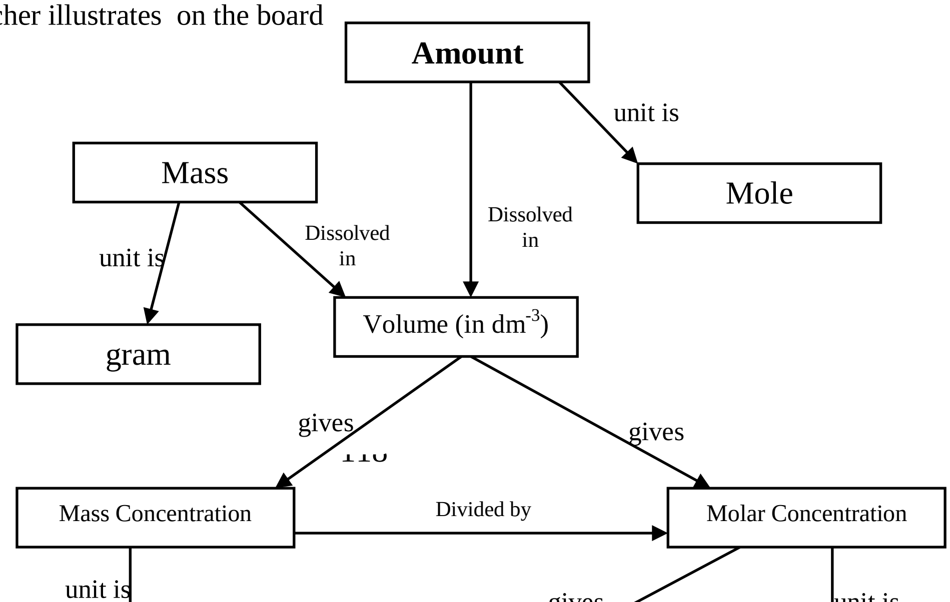


Fig 3.5 Micro concept map on Mole Concept

Step 5 Teacher gives general summary of lesson and clarifies difficult concepts.

Student will construct a micro concept map of chemical quantities and their unit

In group while the teacher goes around to guide the students.

Evaluation Teacher will ask the following questions based on the lesson taught.

i. Define stoichiometry
ii. List at least 5 chemical quantity and their units
iii. What is a mole
iv. To construct a concept map showing the relationship that exist in the listed concepts

Concept mapping strategy: Lesson Plan 3

Week School	Three G.S.S. Jama'a
Date	
Time	
Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2

Topic	Concepts in Stoichiometry
Content	- Amount - Molarity - Molar mass - Mass concentration - Avogadro's atom
Reference Material	Ojokuku, G.O. *Practical Chemistry for Schools and Colleges Gbabeks* Publishers Limited, Ibadan
Behavioral Objectives	At the end of the lesson students will be able to; Define the following a) 1.Amount 2.Molarity 3.Molar mass 4.Mass concentration 5.Avogradors atom b)Give formulas that show the relationships that exist between the concepts C) Construct a concept map to show the relationship that exist between the concepts listed in (a) above.
Previous Knowledge	Students are familiar with chemical quantities and their units
Introduction	Teacher introduces the lesson by asking questions based on the previous knowledge, that is, mention 5 chemical quantities and their unit discussed last week? Teacher further revise the previous week concept map to the students
Presentation	Teacher presents the lesson in the following stepsSSS
Step 1	Teacher writes the following quantities on the board - Amount - Molarity - Molar mass - Mass concentration and - Avogradros number
Step 2	Teacher explains each concepts to the students Amount: The unit of amount of a chemical substance is the mole-abbreviated mol. A mole is the amount of substance which contains as many elementary units as there are atoms in 12.0g of carbo-12

	Molarity: It is the amount of substance in moles, present in $1dm^{-3}$ of solution. Hence it is expressed in mole per dm^3 ($mol.dm^{-3}$) Mass Concentration: Is the mass, in grams of the substance dissolved in $1dm^3$ of solution. It is expressed in grams per dm^3 (gdm^{-3}) Avogadro's Number: It is the number of elementary units in a mole of a substance, which is equivalent to 6.02×10^{23} also called Avogradros constant. Molar Mass: Is the sum of all the atomic masses present in one mole of a substance (compound). It is expressed in gram per mole ($gmol^{-1}$)
Step 3	The teacher explains the relationship that exists between the concepts (amount, molar mass, molarity or molar concentration, mass concentration avogadros number, electron,molecule,atom,ion)by illustrating the concept map on the board. Example

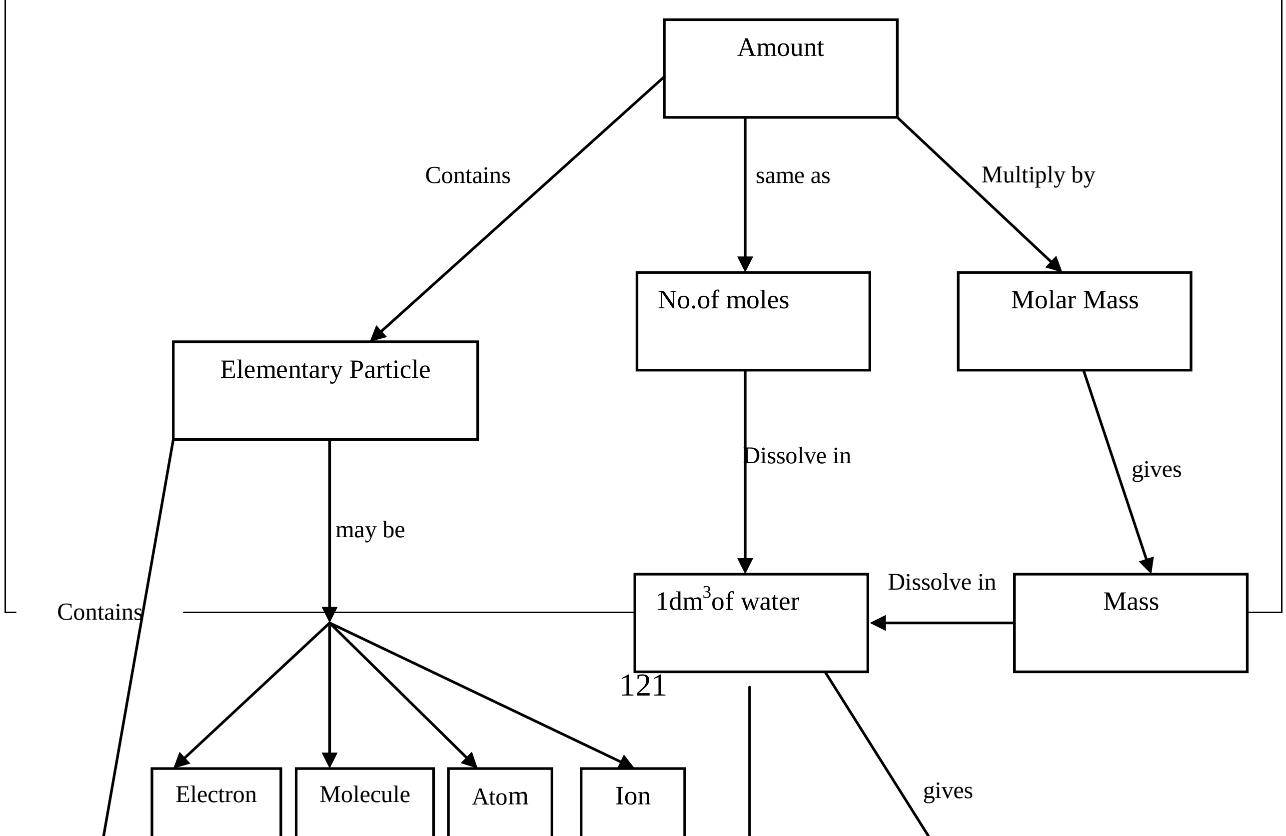


Fig 3.6 Micro Concept map on Mole concept

Step 4 Students activity	Teacher gives summary of the lesson. Students will be provided with a sheet of paper to construct a concept map. The concept are as follow: amount, molar mass, molarity, mass concentration, Avogadro’s number, 6.02×10^{23} ,mole .
Evaluation	Teacher will evaluate the students by asking the following questions: 1 Define the following a. Amount b.Molar mass. c.Mass concentration. d.Molar concentration. e.Avogadro’s number 2.Give formula to show relationship that exist between; a.Molar Mass, Mass Concentration and Molarity b.Amount, Mass and Avogadros number

Concept Mapping Strategy: Lesson Plan 4

Week	Four
SSchool	G.S.S. Jama'a
Date	
Time	
Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Calculation on Mole Concept
Reference Material	Ojokuku, G.O. Practical Chemistry for Schools and Colleges Gbabeks Publishers Limited, Ibadan
Behavioural Objectives	At the end of the lesson students will be able to solve problems on; - Molarity - Amount - Molar mass - Mass concentration - Avogradros number
Previous Knowledge	Students are familiar with molarity, amount, molar mass, mass concentration, Avogadros number and the relationship that exist between them using formula
Introduction	Teacher introduces the lesson by asking questions on their previous knowledge
Presentation	Teacher presents the lesson in the following steps
Step 1	Teacher worked molar masses of some compounds on the board.Teacher call some students to the board to solve molar mass of some compound eg,CO2,HNO3,Ca(OH)2
Step 2	Teacher solved problems on amount and molar mass using the formula Amount= $\frac{Mass}{Molar\, mass}$
Step 3	Teacher solve problems on Avogradros numbers using the formula Amount = $\frac{Mass}{Avogadros\, no}$
Step 4	Teacher calculate molar concentration of substances using the formula

Molar concentration = $\frac{amount\,(in\,mole)}{Volume\,in\,dm^3}$

Evaluation Teacher gives exercise to the students to solve. The questions are;

1. Calculate molar mass of the following (a) HCl (b) Na_2CO_3
2. What is the amount, in moles, of each of the following substances present in
   a. 5.0g of NaOH
   b. 5.6g of Na_2CO_3

Concept Mapping Strategy: Lesson Plan 5

Week	Five
School	GSS Jama'a (snr)
Date	
Time	
Period	
Duration	80 minutes
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Calculation on Mole Concept (continuation)
Reference Material	Ojokuku, G.O. Practical Chemistry for Schools and Colleges Gbabeks Publishers Limited, Ibadan
Behavioural Objectives	At the end of the lesson, students will be able to solve problems on; - Molarity - Amount - Molar mass - Mass concentration
Previous Knowledge	Students are familiar with molarity, amount, molar mass, mass concentration and the relationship that exist between them using formula
Introduction	Teacher introduces the lesson by asking questions on the previous class.
Presentation	Teacher presents the lesson in the following steps
Step 1	Teacher solve problems on the board on mass concentration of a solution using the formula Mass concentration = $\frac{Mass}{Volume\, in\, dm^3}$
Step 2	Teacher solve problems on molarity, molar mass and mass concentration using the formula; Molarity = $\frac{Mass\, concentration}{Molar\, mass}$
Step 3	The teacher summarizes the lesson all over
Evaluation	Teacher evaluates the students by giving class work.

Concept Mapping Strategy: Method Lesson Plan 6

Week Five

School	G.S.S. Jama'a
Date	
Time	
Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Calculation of Percentages of elements in a compound
Reference Material	Ojokuku, G.O. Practical Chemistry for Schools and Colleges Gbabeks Publishers Limited, Ibadan
Behavioural Objectives	At the of the lesson, students will be able to calculate percentages of atom/elements present in a compound
Previous Knowledge	Students are familiar with atomic mass and are able to solve relative molecular mass of compounds
Introduction	Teacher introduces the lesson by asking questions on the previous knowledge.
Presentation	Teacher presents the lesson in the following steps
Step 1	Teacher listed some compound on the board e.g $MgCl_2$, CuO, Na_2CO_3, H_2SO_4 Question: what is the percentages of the underlined elements in the compound
Step 2	Teacher solved the first two compounds listed above using the formula Percentage = $\frac{Atomic\ mass\ of\ element}{\mathrm{Re}\,lative molecular\ mass} \times 100$
Evaluation	Teacher evaluates the students by asking them to solve the last 2 compounds in the question given above by the teacher. In this same week (5th week), the students will be post-tested based on all the treatment they received given SPT while on the 6th week RTQ and MCT will be distributed to the students to fill.

APPENDIX G

LECTURE METHOD : LESSON PLAN 1

Week	One
School	
Date	
Time	
Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Concepts in Stoichiometry
Sub Topic	- Chemical Quantities - Units of Chemical Quantities
Reference Material	Ojokuku, G.O. *Practical Chemistry for Schools and Colleges Gbabeks* Publishers Limited, Ibadan
Behavioural Objectives	At the end of the lesson students will be able to; i. Define stoichiometry of a chemical reaction ii. List some chemical quantities iii. Give the units of chemical quantity iv. Define and explain mole concept
Previous Knowledge	Students are familiar with chemical symbol, compound and how to write chemical equation
Introduction	Teacher introduces the lesson by asking questions based on the previous knowledge
Presentation	Teacher present the lesson in the following steps
Step 1	Teacher explains the objectives of the lesson
Step 2	Teacher defines and explain stoichiometry of a chemical reaction
Step 3	Teacher mentions some chemical quantities with their units to the students. Students should be taking down the points as the lesson progresses
Step 4	Teacher defines and explains mole concept
Step 5	Teacher gives general summary of lesson and clarify difficult concepts
Evaluation	Teacher will ask the following questions based on the lesson taught.

v. Define stoichiometry

vi. List at least 5 chemical quantity and their units

vii. What is a mole

Lecture Method Lesson Plan 2

Week	Two
School	
Date	
Time	
Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Concepts in Stoichiometry
Content	- Amount - Molarity - Molar mass - Mass concentration - Avogradros atom
Reference Material	Ojokuku, G.O. *Practical Chemistry for Schools and Colleges Gbabeks* Publishers Limited, Ibadan
Behavioural Objectives	At the end of the lesson students will be able to; 1. Define the following i. Amount ii. Molarity iii. Molar mass iv. Mass concentration v. Avogradors atom 2. Give formulas that show the relationships that exist between the concepts
Previous Knowledge	Students are familiar with chemical quantities and their units
Introduction	Teacher introduces the lesson by asking questions based on the previous knowledge, that is, mention 5 chemical quantities and their unit discussed last week?
Presentation	Teacher presents the lesson step-by-step
Step 1	Teacher writes the following quantities on the board - Amount

- Molarity
- Molar mass
- Mass concentration and
- Avogradros number

Step 2 Teacher explains each concept to the students

Amount: The unit of amount of a chemical substance is the mole-abbreviated mol. A mole is the amount of substance which contains as many elementary units as there are atoms in 12.0g of carbo-12

Molarity: It is the amount of substance in moles, present in $1dm^{-3}$ of solution. Hence it is expressed in mole per dm^3 ($mol.dm^{-3}$)

Mass Concentration: Is the mass, in grams of the substance dissolved in $1dm^3$ of solution. It is expressed in grams per dm^3 (gdm^{-3})

Avogrados Number: It is the number of elementary units in a mole of a substance, which is equivalent to 6.02×10^{23} also called Avogradros constant.

Molar Mass: Is the sum of all the atomic masses present in one mole of a substance (compound). It is expressed in gram per mole ($gmol^{-1}$)

Step 3 The teacher explains the relationship that exists between the concepts by writing the formula on the board

Step 4 Teacher gives summary of the lesson

Evaluation Teacher will evaluate the students by asking the following questions:

1. Define the following
   a. Amount
   b. Molar mass
   c. Mass concentration
   d. Molar concentration
   e. Avogadros number
2. Give formula to show relationship that exist between;
   a. Molar Mass, Mass Concentration and Molarity
   b. Amount, Mass and Avogadros number

Lecture Method Lesson Plan 3

Week	Three
School	
Date	
Time	
Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Calculation on Mole Concept
Reference Material	Ojokuku, G.O. Practical Chemistry for Schools and Colleges Gbabeks Publishers Limited, Ibadan
Behavioural Objectives	At the end of the lesson students will be able to solve problems on; - Molarity - Amount - Molar mass - Mass concentration - Avogradros number
Previous Knowledge	Students are familiar with molarity, amount, molar mass, mass concentration, Avogadros number and the relationship that exist between them using formula
Introduction	Teacher introduces the lesson by asking questions on their previous knowledge
Presentation	Teacher presents the lesson in the following steps
Step 1	Teacher worked molar masses of some compounds on the board
Step 2	Teacher solved problems on amount and molar mass using the formula Amount= $\frac{Mass}{Molar\,mass}$
Step 3	Teacher solve problems on Avogradros numbers using the formula Amount = $\frac{Mass}{Avogadros\,no}$
Step 4	Teacher calculate molar concentration of substances using the formula

Molar concentration = $\frac{amount\ (in\ mole)}{Volume\ in\ dm^3}$

Evaluation Teacher gives exercise to the students to solve. The questions are;

3. Calculate molar mass of the following (a) HCl (b) Na_2CO_3
4. What is the amount, in moles, of each of the following substances present in
   c. 5.0g of NaOH
   d. 5.6g of Na_2CO_3

Lecture Method Lesson Plan 4

Week	Four
School	G.S.S.Basawa (Snr)
Date	
Time	
Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Calculation on Mole Concept (continuation)
Reference Material	Ojokuku, G.O. Practical Chemistry for Schools and Colleges Gbabeks Publishers Limited, Ibadan
Behavioural Objectives	At the end of the lesson, students will be able to solve problems on; - Molarity - Amount - Molar mass - Mass concentration
Previous Knowledge	Students are familiar with molarity, amount, molar mass, mass concentration and the relationship that exist between them using formula
Introduction	Teacher introduces the lesson by asking questions on the previous class.
Presentation	Teacher presents the lesson in the following steps
Step 1	Teacher solve problems on the board on mass concentration of a solution using the formula Mass concentration = $\frac{Mass}{Volume\, in\, dm^3}$
Step 2	Teacher solve problems on molarity, molar mass and mass concentration using the formula; Molarity = $\frac{Mass\, concentration}{Molar\, mass}$
Step 3	The teacher summarizes the lesson all over
Evaluation	Teacher evaluate the students giving class work.

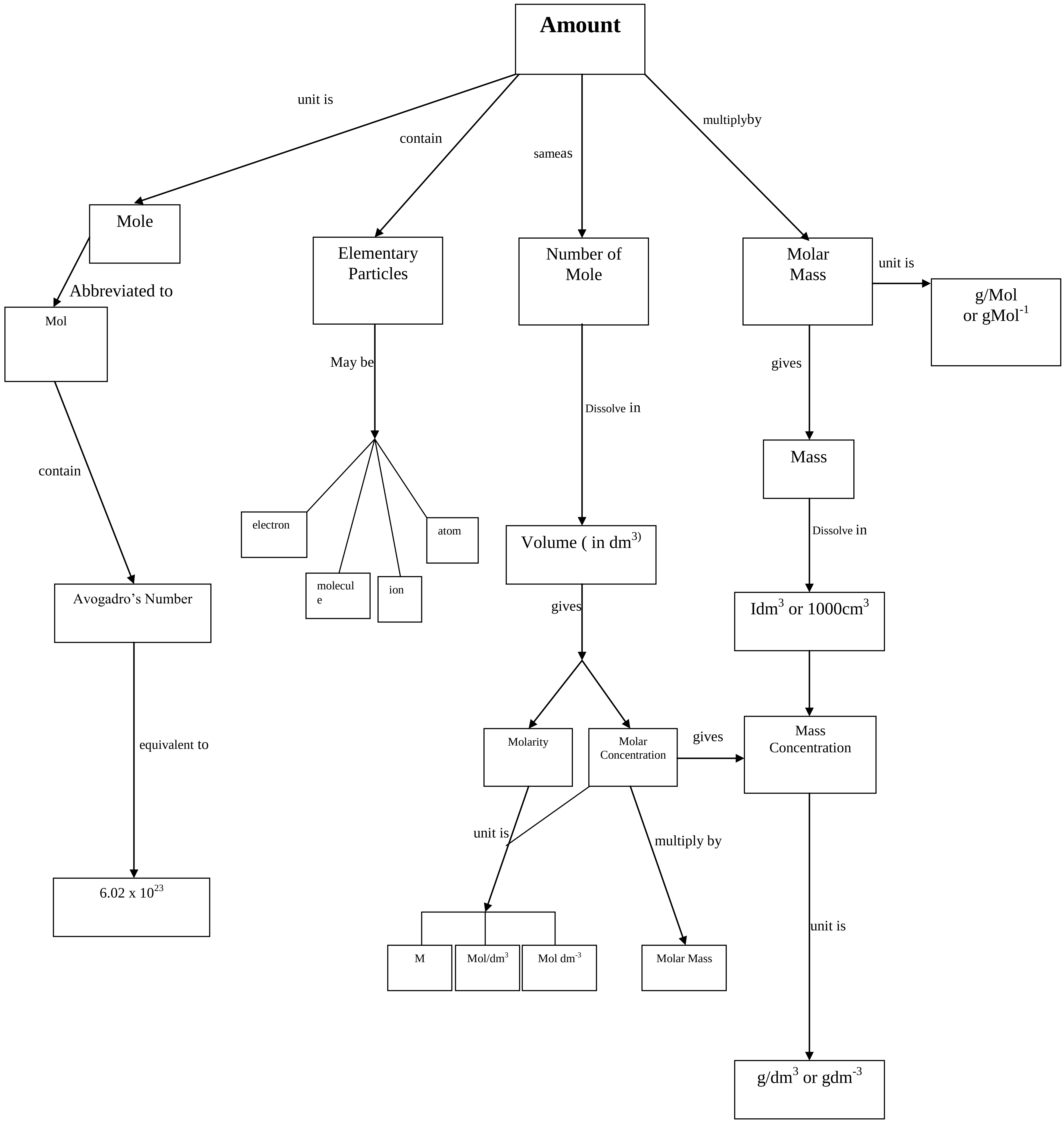
Lecture Method Lesson Plan 5

Week Five

School	G.S.S.Basawa (Snr)
Date	
Time	
Period	
Duration	40 min
Average Age of Students	16 years
Subject	Chemistry
Class	SS 2
Topic	Concepts in Stoichiometry
Sub Topic	Calculation of Percentages of elements in a compound
Reference Material	Ojokuku, G.O. Practical Chemistry for Schools and Colleges Gbabeks Publishers Limited, Ibadan
Behavioural Objectives	At the of the lesson, students will be able to calculate percentages of atom/elements present in a compound
Previous Knowledge	Students are familiar with atomic mass and are able to solve relative molecular mass of compounds
Introduction	Teacher introduces the lesson by asking questions on the previous knowledge.
Presentation	Teacher presents the lesson in the following steps
Step 1	Teacher listed some compound on the board e.g $MgCl_2$, CuO, Na_2CO_3, H_2SO_4 Question: what is the percentages of the underlined elements in the compound
Step 2	Teacher solved the first two compounds listed above using the formula Percentage = $\frac{Atomic\ mass\ of\ element}{\mathrm{Re}\ lative\ molecular\ mass} \times 100$
Evaluation	Teacher evaluates the students by asking them to solve the last 2 compounds in the question given above by the teacher. In this same week (5th week), the students will be post-tested based on all the treatment they received while on the 6th week questionnaire for reflective thinking will be distributed to the students to fill.

APPENDIX H

TEACHER MADE / EXPERT CONCEPT MAP ON MOLE CONCEPT



APPENDIX I

REFLECTIVE THINKING QUESTIONNAIRE (RTQ)

Guidance for completing this questionnaire

This is NOT a test. There are no ‘right’ or ‘wrong’ responses to the statements that follow. A response is only ‘right’ if it reflects your personal reaction and the strength of your reaction as accurately as possible.

Please circle the appropriate letter to indicate the level of your agreement with the statements about your actions and thinking in this lesson so far.

A - Definitely agree

B - Agree only with reservation

C - Only to be used if a definite answer is not possible

D - Disagree with reservation

E - Definitely disagree

NOW please read through the statements and respond quickly.

Gender: BOY………. GIRL……………

1	When I am working on some activities, I can do them without thinking about what I am doing	A	B	C	D	E
2	This lesson requires us to understand concepts taught by the teacher	A	B	C	D	E
3	I sometimes question the way others do something and try to think of a better way	A	B	C	D	E
4	As a result of this lesson I have changed the way I look at myself	A	B	C	D	E
5	In this lesson we do things so many times that I started to do them without thinking about it	A	B	C	D	E
6	To pass this lesson you need to understand the content	A	B	C	D	E
7	I like to think over what I havse been doing and consider alternative way of doing it	A	B	C	D	E
8	This lesson has challenged some of my firmly held ideas	A	B	C	D	E

9	As long as I can remember notebook for examination, I do not have to think too much	A	B	C	D	E
10	I need to understand the concepts taught by the teacher in order to perform practical tasks	A	B	C	D	E
11	I often reflect on my actions to see whether I could have improved on what I did	A	B	C	D	E
12	As a result of this lesson I have changed my normal way of doing things	A	B	C	D	E
13	If I follow what the teacher says, I do not have to think too much on this lesson	A	B	C	D	E
14	In this lesson you have to continually think about the concept you are being taught	A	B	C	D	E
15	I often reappraise my experience so that I can learn from it and improve my next performance	A	B	C	D	E
16	During this lesson I discovered faults in what I had previously believed to be right	A	B	C	D	E

Source: Adapted from Kember et al (2000)

APPENDIX J

THE WORDING OF ITEMS WITH EACH SCALE OF QRT

SCALE	
No.	**Habitual Action**
1	When I am looking on some activities, I can do them without thinking about what I am doing
5	In this lesson we do things so many times that I started to do them without thinking about it
9	As long as I can remember handout material for examination, I do not have to think too much
13	If I follow what the teacher says, I do not have to think too much on this lesson
	Understanding
2	This lesson requires us to understand concepts taught by the teacher
6	To pass this lesson you need to understand the content
10	I need to understand the material brought by the teacher in order to perform practical tasks
14	In this lesson you have to continually think about the material you are being taught
	Reflection
3	I sometimes question the way others do something and try to think of a better way
7	I like to think over what I have been doing and consider alternative way of doing it
11	I often reflect on my actions to see whether I could have improved on what I did
15	I often reappraise my experience so that I can learn from it and improve my next performance
	Critical Reflection
4	As a result of this lesson I have changed the way I look at myself
8	This lesson has challenged some of my firmly held ideas
12	As a result of this lesson I have changed my normal way of doing thinks
16	During this lesson I discovered faults in what I had previously believed to be right